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STATE MINING LAWS ON THE USE OF ELECTRICITY IN AND ABOUT COAL MINES

BY

L. C. ILSLEY

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STATE MINING LAWS RELATING TO THE USE OF ELECTRICITY IN AND ABOUT COAL MINES.

By L. C. Ilsley.

INTRODUCTION.

Coal mining is more widely distributed throughout the United States than is generally known, as 30 States are credited with having coal mines. In 1919 twenty-three of these States each produced at least a million tons of bituminous coal, and all the States produced about 560,000,000 tons. In addition, Pennsylvania produced about 85,000,000 tons of anthracite.

Twenty-eight States have regulations prepared by commissions or have enacted laws governing the operation of coal mines. Pennsylvania has separate codes for the anthracite and bituminous fields. The codes may be classified as follows: Twelve distinctly coal-mining codes; eight codes that are essentially coal mining, but also apply to other mines; five codes that are subdivided, referring partly to coal mines and partly to other mines; and four codes that are essentially metal mining, but apply in part or in whole to coal mining.

The first State to have a coal-mining law was Pennsylvania, which enacted a law, for Schuylkill County only, in 1869. The first State to enact a coal-mining law governing all the coal mines in the State was Illinois in 1872, followed by Ohio in 1873. Pennsylvania in 1870 enacted a law for anthracite mines only, but did not enact similar laws for bituminous mines until 1877. At least 10 other States enacted coal-mining laws between the years 1870 and 1890.

Before 1890 electricity was little used in coal-mining operations and therefore practically no provisions governing the installation, inspection, or maintenance of electrical equipment were made in any of the laws enacted up to 1890. In the law of Colorado, approved April 8, 1885, there is a reference to the use of telephones, probably the first reference to electrical equipment of any kind in a State-mining code.

Most of the mining codes have been changed from their original form by amendment or by complete revision. In some of the early changes a casual reference is made to the use of electricity or to the handling of electrical equipment. In 1911 Pennsylvania added numerous regulations governing the use of electricity to its bituminous code; California and Washington have since included similar regulations in their codes, and some other State codes have partial regulations on the subject. At present 21 States make some reference in their coal-mining laws to the use of electricity or to the operation of electrical equipment.

During the three decades, 1890–1920, electricity as applied to coal mining made rapid progress until to-day there remains hardly a task or an operation connected with coal mining that is not directly or indirectly concerned with the use of electricity. From the time the miner takes his electric cap lamp in the morning until he has completed his task at night he is continually using electricity or electrical equipment. The electric signal tells the hoisting engineer when to start and stop the hoisting engine. The lights at the several levels and at dangerous crossings throughout the mine are usually electric. The telephone is a part of the equipment necessary underground. Electric shot firing and electric shot-firing systems are becoming widely used. Electric pumps handle much of the water in the mines. The haulage of coal is done largely by electric trolley and by storage-battery locomotives and electrically operated hoists. The mining of coal is very generally done by electrically operated coal-cutting equipment and electric drills. Each year some new electrical device is introduced.

Electrical equipment for mines, in order to be safe and efficient, must be properly designed, carefully installed, inspected at regular intervals by competent men, and maintained in good working condition. In general, the best way to obtain satisfactory electrical equipment for mine service and to insure its proper installation, inspection, and maintenance, is for each State to make and enforce fundamental rules and regulations relating to the use of electricity and electrical equipment in and about coal mines.

The rapidity with which electrical equipment has entered into the many phases of coal mining has exceeded greatly the advance of regulations governing its use. Even the best electrical mining codes in force need modernizing, and some States have even neglected to mention the use of electricity in their mining laws.

The purpose of this paper is to show by comparison the relative attention given by the law-making bodies of the different States to the safe use of electricity in coal mines; to list and explain the purpose of the more important regulations; and to cite examples of regulations now in effect either as a part of a State code or as rules issued by State industrial commissions.

ACKNOWLEDGMENTS.

Acknowledgment is made to the different State mining departments that have furnished for this study copies of State regulations.

Criticisms of the text by E. A. Holbrook, formerly superintendent of the Pittsburgh experiment station, and by other engineers at the station have added materially to the value of the paper.

Credit is due R. A. Kearns and H. B. Brunot, junior electrical engineers, for their assistance in the preparation of the paper and in performing routine work connected with checking the numerous references to State regulations.

OBJECT OF ELECTRICAL REGULATIONS.

All electrical rules, regulations, and laws relating to the use of electricity in coal mines have as their aim one or more of the following objects: To prevent persons or animals from receiving an electrical shock, to prevent mine fires, to prevent explosives accidents, to prevent mine explosions, to prevent other accidents that may be caused by the use of electrical equipment, and to prolong the useful life of the apparatus.

CLASSIFICATION.

The laws or rules enacted by the several States with reference to the use of electricity in coal mines have been divided into three main groups for convenience of study, and in order that the exact progress made by each of the several States may be more clearly shown, these groups have been classified as follows: Class I, rules relating to general safety in use of electricity underground; class II, rules relating to underground electrical apparatus; class III, rules relating to underground electrical circuits.

RULES OF CLASS I.

NATURE AND PURPOSE.

In class I are grouped several general rules of recognized value in the prevention of accidents and in the maintenance of equipment, and also special rules intended to prevent accidents from electrical shocks. The rules in this group are such as no State can afford to omit if it wishes to secure the greatest possible protection for those working with and about electrical equipment.

Class I has been subdivided under 20 headings and a table arranged showing how far the different States have progressed with respect to specific rules of this kind. If a State code has made any distinct reference to a given subdivision, it has been credited with a rule, although the rule may be inadequate. The different States have been rated on the basis of the number of subdivisions covered by each State. The table follows.

TABLE 1.—*States having rules of Class I, those relating to general safety.*

States.	Electrical terms defined.	Voltage classification.	Voltage restrictions, regulations, etc.	Supervision of electrical equipment.	Periodic inspection and maintenance.	Report of defective equipment.	Posting of notices and warnings.	Posting of instructions for resuscitation.	Precautions to prevent injury to men handling electric wires or equipment.	Prohibition to cause another to receive an electric shock.	Prohibition to handle or tamper with electrical equipment.	Protection of machine terminals.	Grounding of metallic frames of electrical apparatus and metallic coverings of cables and wires.	Protection against fires caused by electrical equipment.	Regulation as to capacity of electrical equipment.	Rating of electrical equipment to be given.	Plan map of electrical system.	Locomotive pits and repair shops.	Precautions in the use of electricity in mining with respect to the transportation and storage of explosives.	Provision for adequate State inspection.	Rating.
Alabama	Yes.	Yes.	Yes.			Yes.					Yes.										25
California	Yes.	Yes.	Yes.		[1] Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	(2)	[3] Yes.	Yes.		Yes.	(4)	80
Colorado										Yes.	Yes.									(5)	10
Illinois			[6] Yes.								(7)								Yes.		10
Iowa																			Yes.		5
Kansas											(7)								Yes.		5
Kentucky			[8] Yes.																		5
Michigan																			Yes.		5
Montana					[9] Yes.																5
New Mexico											[10] Yes.										5
North Dakota					[9] Yes.																5
Ohio			Yes.																Yes.	Yes.	15
Pennsylvania (bituminous)	Yes.	Yes.	Yes.	Yes.	[11] Yes.	Yes.	Yes.	Yes.	Yes.		Yes.	Yes.	Yes.	Yes.	Yes.	[12] Yes.	Yes.		Yes.		85
Utah					[13] Yes.																5
Washington	Yes.	Yes.	Yes.		(14)	Yes.	Yes.		Yes.		Yes.		Yes.	Yes.	(15)	[12] Yes.			Yes.		55
West Virginia					Yes.	(16)					Yes.								Yes.		15
Wyoming							Yes.														5

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[1] Requires that the superintendent or some one appointed by him shall inspect all equipment and appliances in and about a mine, but does not specifically require periodic inspection. Provides for maintenance when such inspection is made. Periodic inspection is required for ground detectors.

[2] Permits use of fuses instead of circuit breakers on circuits under 25-kilowatt capacity and motors under 40 horsepower. Regulates capacity of switches used on branch circuits and of all fuses.

[3] Rating of fuses must be shown.

[4] Recommends that plans of initial electrical installations be sent to the industrial accident commission.
[5] Requires that commissioner investigate, report, and record advancement in the application of electricity.
[6] Trolley wires or other exposed electrical wires shall not carry a voltage above 275 volts.
[7] Forbids injuring or tampering with any appliance or machine.
[8] In new installations positive conductors carrying more than 300 volts shall be insulated.
[9] Refers to hoisting equipment only.
[10] Forbids tampering with electric lights or wires.
[11] Refers to inspection of inclosed motors and switches; also requires daily determination of condition of ungrounded system with respect to grounds.
[12] Refers to circuit breakers and fuses.
[13] Requires daily inspection of electric safety lamps.
[14] Requires daily inspection of trailing cables.
[15] High-pressure wires to have carrying capacity, according to rules of National Board of Fire Underwriters.
[16] Machine men required to report defects.

Table 1 shows that 17 States have rules or laws covering one or more of the subdivisions. Pennsylvania (bituminous), California, and Washington, in the order named, have given by far the most consideration to the enactment of electrical regulations. Thirteen other States with coal mines have not provided general protective measures.

DISCUSSION OF THE RULES OF CLASS I.

In the paragraphs following each of the subdivisions already considered under Class I is discussed with respect to the purpose of the rule, and when feasible an example of the rule or regulation is given. Most of these examples are selected from State laws or regulations already in force.

ELECTRICAL TERMS DEFINED.

In any State electrical code the first point to be considered is a definition of the electrical terms used, as the absence of such definitions may lead to a lack of understanding of the law. It should be the purpose of those formulating a law to make its meaning clear enough to enable anyone at all familiar with the subject to recognize the object of each rule and the necessity and means of carrying out its provisions. Definitions do not materially lengthen a code, and do make plain its purpose and application.

Three States—California, Pennsylvania (bituminous), and Washington—have recognized the need of defining electrical terms. In all the States still more terms should be defined and some modification made in the present definitions. In the electrical and mining industries that are progressing with such rapidity even definitions do not remain fixed, but are subject to change as new methods and new machinery come into use. An example of electrical terms defined in the Washington State law (see Table 5) follows:

Potential.—The terms "potential" and "voltage" are synonymous and mean electrical pressure.

Difference of potential.—The expression "difference of potential" means the difference of electrical pressure existing between any two points of an electric system, or between any point of such system and the earth, as determined by a voltmeter.

Potential of a circuit.—The potential or voltage of a circuit, machine, or any piece of electrical apparatus is the potential normally existing between the conductors of such circuit or the terminals of such machine or apparatus. * * *

Grounding.—Grounding any part of an electric system shall consist in so connecting such part to the earth that there shall be no difference of potential between them.

Underground station.—An underground station is herein considered as any place where electrical machinery is permanently installed.

VOLTAGE CLASSIFICATION.

The voltage of a circuit may range from that of a dry cell—about 1.2 volts—to the 200,000 volts used in a long-distance high-voltage transmission line. Therefore it is necessary when speaking of voltage

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in a mine code to have some means of identifying a given amount of voltage. Usually the voltage of circuits and apparatus is divided for this purpose into three classes—low, medium, and high; low voltage includes up to 300 volts; medium voltage, from 300 to 600 volts; and high voltage, above 600 volts. No efficient electric code can be formulated unless some classification of voltage is adopted.

Alabama, California, Pennsylvania (bituminous), and Washington codes include classification of voltage. An example taken from the Alabama code (see Table 5) is given:

> Three systems of voltages are described as follows: Class 1. Low, 300 volts direct current or 240 volts alternating current or less. Class 2. Medium, between 300 volts and 600 volts direct current or 240 volts and 480 volts alternating current. Class 3. High, 600 volts direct current or 480 volts alternating current and higher.

VOLTAGE RESTRICTIONS AND REGULATIONS.

Restrictions are necessary because each gradation in voltage necessitates a different rule covering the design, installation, operation, and maintenance of equipment in that class in order to insure to the apparatus, whatever its class, the same relative safety and a reasonable period of service to the user. A rule that might be proper for the installation of a 25-volt signal circuit would not be suitable in the case of a 250-volt trolley system, and entirely inadequate to protect a 2,300-volt installation. It is evident that low-voltage circuits may be permitted where it would not be proper to allow high-voltage circuits. Five States, Alabama, California, Ohio, Pennsylvania (bituminous), and Washington include such provisions in their laws. Quotations from the Alabama code (see Table 5) are given as follows:

> RULE 3. No apparatus or conductors carrying a voltage within class three shall be allowed in or about working places. RULE 4. Portable apparatus using a voltage of class three are prohibited. RULE 5. Electrical equipments installed after this date shall not use any voltage higher than that in class one in or about working places. This does not prohibit the use of voltages defined in classes two and three (except in or about working places) provided such apparatus is installed and maintained according to these regulations. RULE 7. The three-wire double-voltage system having a maximum voltage within class two may be used provided the neutral is effectively grounded and the maximum voltage between any conductor and the earth complies with these requirements.

SUPERVISION OF ELECTRICAL EQUIPMENT.

In any mine where electrical equipment is used, the placing of a competent person in charge of it is essential, in order that there may be proper installation, inspection, and maintenance. The average mine official is too busy with his other duties to give enough attention to this matter, even if he has the necessary training; therefore, it should be definitely specified in every electrical coal-mining code that a man fitted for the position should devote his entire time to directing or actually performing the work connected with installing, inspecting, and maintaining electrical equipment at each mine.

The Pennsylvania (bituminous) law is the only one having this provision (see Table 5), which is quoted as follows:

> At every mine where electricity is used below ground, for power, there shall be employed a competent mine electrician, who shall have full charge of the electrical apparatus in the mine, but shall be subject to the authority of the mine foreman.

PERIODIC INSPECTION AND MAINTENANCE.

There should be a specific rule requiring regular periodic inspection and maintenance of electrical equipment and circuits for these reasons:

Parts such as commutators, brushes, bearings, and controller contacts deteriorate by wear and should be repaired or replaced before the apparatus has been damaged.

Dirt, grease, and coal dust accumulate, and if not removed may cause grounds or short circuits.

Oil and battery electrolytes evaporate, leak out, become dirty, and lose their mechanical and electrical effectiveness.

Insulation deteriorates with continued exposure to heat or dampness; grounds and short circuits result.

Falls of roof, wrecks, timbering, and blasting cause damage to apparatus and circuits.

Protective apparatus such as relays, circuit breakers, fuses, headlights, signals, and bells need to be carefully maintained.

There is no State law that properly provides for the periodic inspection and maintenance of equipment. The following suggested rule from Technical Paper 138 (see Table 5) of the Bureau of Mines shows a type of regulation that might be adopted to cover this subject:

> At each mine where electricity is used underground, a systematic inspection of all wiring and equipment shall be made at regular intervals, at least once every month. A report of each inspection shall be made by the mine electrician or inspector, and a copy of this report shall be furnished to the mine foreman and kept on file at the mine. The report shall definitely state the condition of each main and branch, power and lighting circuit, and of the motors and controlling appliances of each locomotive, mining machine, pump, hoist, or other piece of electrical apparatus connected to the electrical system of the mine.

REPORT OF DEFECTIVE EQUIPMENT.

As it is impracticable to detail an electrician to look after each separate piece of apparatus, and as the regular periodic inspection by the person responsible for the maintenance of equipment can not take the place of the constant watchfulness and care so essential to the safe operation of electrical equipment, it is important that unusual conditions of electrical equipment—such as displaced wiring due to roof falls or blasting, heating of parts, arcing, bad sparking at brushes, or electrically charged machine frames—be reported immediately by the observer to the man responsible for the maintenance of the equipment or to his authorized agent.

Alabama, California, Pennsylvania (bituminous), and Washington have given attention to this in their codes. The following quotation is taken from Alabama's code (see Table 5):

> Any unusual arcing, sparking, or heating of any of the electrical equipment shall be reported at once to the proper mine officer by the attendant or any other person having knowledge of same.

POSTING OF NOTICES AND WARNINGS.

Notices should be required at all places where a caution will tend to prevent electrical accidents. Wherever electrical equipment or any part thereof is of such a nature as to offer an electrical hazard, signs should be prominently posted warning all persons of the danger, and prohibiting those not qualified from repairing or handling the equipment.

California, Pennsylvania, Washington, and Wyoming have rules or regulations requiring the posting of notices. An example taken from the Washington code (see Table 5) follows:

> All high-voltage machines, apparatus, and lines shall be so marked as to clearly indicate that they are dangerous by the use of the word "danger" placed at frequent intervals.

POSTING OF INSTRUCTIONS FOR RESUSCITATION.

Persons receiving an electrical shock need artificial respiration similar to that given a person overcome by gas or rescued from drowning. A few moments' delay or improper treatment may result fatally, whereas, with quick and proper methods of resuscitation, a life may be saved. Therefore a chart showing proper resuscitation methods should be placed in every underground station where electricity is used, in hospitals and in first-aid stations, charts should be kept in good condition, and visible. Those working with and about electrical equipment should be instructed in methods of resuscitation.

Pennsylvania (bituminous) laws and California regulations have rules relating to this subject. California's code (see Table 5) is quoted as follows:

> Instructions for the resuscitation of persons suffering from electric shock shall be posted at the entrance of the mine in every generating station or substation, and in all underground electric stations. All employees working with electrical apparatus shall be required by the mine superintendent to familiarize themselves with these instructions, and shall be capable of applying them before entering upon such work.

PRECAUTIONS IN HANDLING ELECTRIC WIRES OR EQUIPMENT.

At times it becomes necessary for the electrician or station attendant to handle electric equipment or circuits while the equipment or circuit is "alive" or charged with electricity. This work should never be done excepting under the direction or instruction of the man in charge of the electrical equipment.

Whenever a person handles live equipment, precautions must be taken against receiving an electrical charge through the body. This precaution may be carried out in either of two ways—(1) by thoroughly insulating the hands by rubber gloves, or (2) by insulating the body by standing on a rubber mat, dry board, or a platform supported on glass insulators. When handling circuits of more than 250 volts the utmost precaution should be taken. California laws forbid anyone but the electrician to work on live apparatus, and forbids his working on live apparatus above 115 volts. However, no specific reference is made to circuits.

Means for protection against shock are required by California, Pennsylvania (bituminous) and Washington. A quotation taken from the Washington code (see Table 5) follows:

> *Precautions against shock.*—Gloves or mats of rubber or other suitable insulating material shall be provided and used by persons so engaged when repairs are made to the live parts of any electrical apparatus, or when the live parts of electrical apparatus have to be handled for the purpose of adjustment.

PROHIBITION TO CAUSE ANOTHER TO RECEIVE AN ELECTRIC SHOCK.

To guard against the practical joker who often, in ignorance of the possible danger to the victim, sets electrical traps, it is prohibited for employees to cause another to receive an electric shock. This practice should be discouraged in every way. Not only is there danger of causing actual death, but in the more ignorant class of workmen fear is developed that lessens efficiency and hinders the performance of regular tasks. As one would hardly set a trap with loaded pistols, neither should one cause another to receive an electric shock which might prove just as fatal. The rule (see Table 5) adopted by the States of California and Colorado provides for this as follows:

> No person working in or about a mine shall willfully cause another person to receive an electric shock.

PROHIBITION TO HANDLE OR TAMPER WITH ELECTRICAL EQUIPMENT.

The purpose of a rule prohibiting employees to tamper with electrical equipment is readily understood, although its full benefit may not be appreciated. A switch thrown at the wrong time may convey energy to circuits upon which men are working; it may set off a charge of explosives, or give the wrong signal to a motorman. Persons having only a slight knowledge of electricity, may do irreparable damage to apparatus or injure themselves in attempting to handle electrical equipment without authority. Such a regulation would also tend to prevent malicious mischief. Seven States, Alabama, California, Colorado, New Mexico, Pennsylvania (bituminous), Washington, and West Virginia have provisions in their codes forbidding handling or tampering with wires or equipment. Rules covering this question most thoroughly are those of California (see Table 5), which follow:

> No person shall, without authority, handle electric wires or conductors, or electrical apparatus of any kind, or enter an electrical machine room or underground station.
>
> * * *
>
> Any person who shall willfully damage, or, without authority, alter or make connection to any portion of a mine electrical system, shall be guilty of a misdemeanor.

PROTECTION OF MACHINE TERMINALS.

The frames of electrical equipment, as motors, transformer, and oil switches under normal conditions are not charged with electricity. This statement, however, is not true of the terminal points where the wires enter or leave the equipment, and it is necessary, therefore, that these points be properly protected by insulation, in order that a person working around the electrical equipment shall not make accidental contact with the terminals and suffer consequent shock or burns.

Two States, California and Pennsylvania (bituminous), have provisions for the protection of machine terminals in their codes. That of California (see Table 5) is to be preferred in that it includes all voltages.

> All exposed terminals on underground machines shall be protected with properly designed insulating covers of suitable material, or with metal covers connected to earth.

GROUNDING OF METALLIC FRAMES OF ELECTRICAL APPARATUS AND METALLIC COVERINGS OF CABLES AND WIRES.

By the term "grounding" is meant making an electrical connection from the object grounded to the earth. The purpose of the rule for grounding metallic frames and coverings of wires is to prevent an electric shock should a person touch the frames of apparatus or the metallic covering of cables after they had become charged with electricity owing to failure of the insulation.

All electrical apparatus has certain parts which are designed as paths for the electric current. The current is kept in these paths by the use of insulation, such as wood, paper, cloth, or mica. If the insulation deteriorates or becomes wet, the electric current may leak through and charge the frame of the apparatus or armor of the circuit. By properly grounding the frame or armor the leakage is reduced to zero voltage and does not cause a shock if a person accidentally or intentionally touches the frame or armor. If the frame of the apparatus or the armor of a cable is not grounded, and a failure of insulation occurs, a person touching the frame or the armor may receive a dangerous shock.

California, Pennsylvania (bituminous), and Washington codes have regulations governing the grounding of electrical equipment and the metallic coverings of cables and wires. The California regulation (see Table 5) follows:

> The frames and bed plates of generators, transformers, compensators, rheostats and motors, installed underground shall be effectively grounded. All metallic coverings, armoring of cables, other than trailing cables, and the neutral wire of three-wire systems shall also be grounded.

PROTECTION AGAINST FIRES CAUSED BY ELECTRICAL EQUIPMENT.

A fire in a coal mine is a serious menace to life and property, as it threatens the miner with suffocation and may result in complete destruction of the workings. There should be proper means at hand to extinguish any fire that may occur in or near underground stations.

California, Pennsylvania (bituminous), and Washington provide rules on this subject in their codes. The Washington code (see Table 5) follows:

> Fire equipment of an approved type shall be kept in electrical stations and transformer rooms, ready for immediate use in extinguishing fires.

REGULATION AS TO CAPACITY OF ELECTRICAL EQUIPMENT.

All electrical equipment is limited in capacity. It is necessary, therefore, to prescribe limits beyond which equipment must not be loaded in order to prevent danger of breakdown from overload and the consequent fire hazard. No one would attempt to use a 10-horsepower engine to drive a 30-horsepower pump, yet an inexperienced person might attempt to run a 60-horsepower motor from a 25-kilovolt ampere transformer with a capacity of approximately 33 horsepower. Lack of understanding of the limitation of electrical equipment through ignorance of electrical terms is the cause of many errors.

To insure safe carrying capacity for equipment, a code should embody specific rules requiring equipment to be of ample size to perform the work. The only State having regulations with respect to capacity of electrical equipment is Pennsylvania, in the following provision (see Table 5):

> All electrical apparatus and conductors shall be sufficient in size and power for the work they may be called upon to do, and, as hereinafter prescribed, efficiently covered

or safeguarded, and so installed, worked, and maintained as to reduce danger from accidental shock or fire to the minimum, and shall be of such construction, and so worked, that the rise in temperature caused by ordinary working will not injure the insulating materials.

RATING OF ELECTRICAL EQUIPMENT TO BE GIVEN.

The object of specifying the rating of equipment is to give the user definite knowledge of what the equipment was designed to do, in order that he shall have no excuse for overloading or otherwise misusing it. As there is no State law making adequate provisions for this feature, the following rule is suggested:

> Every motor, transformer, switch, or other piece of electrical apparatus shall show by name plate or suitable stamping in the metal parts thereof, the name of the manufacturer, the capacity of the equipment, and the duty for which it is intended. If of a rotating type, the revolutions per minute shall also be stated. The name-plate lettering or the stamping shall be readily legible. If a plate is used, it shall be securely fastened to the equipment and shall not be removed therefrom.

PLAN MAP OF ELECTRICAL SYSTEM.

Every mine having electrical equipment should have a plan map showing the location of electrical apparatus and the lines through which the energy to and from such apparatus is distributed. Not only will such a map be of value to the mine owner in solving questions of power distribution, but it will be of service in keeping both company and State inspectors informed as to installations that should be regularly inspected. In case of disaster a map of this kind will be of inestimable benefit in rescue and recovery work. Two States, California and Pennsylvania (bituminous), have rules of this character. The Pennsylvania rule (see Table 5) declares as follows:

> A plan map shall be kept at the mine showing the location of all stationary electrical apparatus in connection with the mine electrical system, including permanent cables, conductors, light, switches, and trolley lines. The plan shall be of sufficient size to show clearly the position of such apparatus, and the scale shall not be less than 200 feet per inch. There shall be stated on the plan the capacity in horsepower of each motor, and in kilowatts of each generator or transformer, and the nature of its duty. Such plans shall be corrected as often as may be necessary to keep them up to date, at intervals not exceeding six months.

LOCOMOTIVE PITS AND REPAIR SHOPS.

No State coal-mining code has yet been enacted that includes regulations with respect to open motor pits or to machinery used in underground electrical repair shops. Motor pits should be provided either with removable covers, or the rooms in which the pits are located should be fenced off by locked gates. Machinery in underground electrical repair shops should be safeguarded by rules covering both electrical and mechanical hazards.

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PRECAUTIONS IN THE USE OF ELECTRICITY WITH RESPECT TO THE TRANSPORTATION AND STORAGE OF EXPLOSIVES.

Electricity, if properly controlled, is useful as a means of firing explosives, but otherwise is very unsafe. An electric current always chooses the path of least resistance for completing its circuit, and if by any chance explosives are a part of that circuit a serious accident may result.

The more common explosive accidents caused by electricity are the result of the transportation of explosives by electric motors and in the storage or handling of explosives in the vicinity of electric wires or apparatus.

Explosives should never be hauled by electric locomotives, or handled or transported by any means in the vicinity of electric wires or apparatus unless the explosives are placed in a covered and insulated box. Under no conditions should they be placed on a locomotive. Explosives should not be stored or temporarily placed near wires or electrical equipment. When carried by hand the utmost precaution should be taken not to let them come into contact with an electric circuit or electric equipment.

California, Iowa, Kansas, Michigan, Ohio, Pennsylvania (bituminous), Washington, and West Virginia have special regulations governing the haulage of explosives by electric motors. Illinois permits taking into a mine sufficient explosives for a day's work, provided all electric current is shut off in the mine at the time. California and West Virginia have regulations covering the storage of explosives in the vicinity of electric wires and equipment.

Quotations from the regulations (see Table 5) of California and West Virginia follow:

CALIFORNIA.

Explosives shall not be carried underground on an electric locomotive, and no one except the train crew shall be allowed to ride on a train carrying explosives.

Explosives shall not be placed or left within 5 feet of live electric wires. * * *

WEST VIRGINIA.

Employees are warned as to the danger of handling powder or other explosive in a rough or careless manner, and opening the same with any kind of sharp or blunt instrument. Powder or other explosives should never be thrown about, but should always be carried and laid down carefully, and kept clear of electric wires, open lights, or fire of any kind. Powder or other explosives must not be handled on or in motor cars propelled or controlled by electric current unless inclosed in nonconducting boxes approved by the district inspector. * * *

By combining the essential features of both codes, a comprehensive rule covering this phase of protection can be formulated.

PROVISION FOR ADEQUATE STATE INSPECTION.

In order that electrical installations shall be adequately inspected it is necessary either that the State inspector, or some other person in the employ of the State, shall know the fundamentals of the theory of electricity and also have practical knowledge of the uses and dangers of electricity as applied to mining operations. This can be accomplished by requiring State mine inspectors to have such knowledge, by making provision for State electrical inspectors in the mine inspection department, or by the employment of properly qualified persons to work under the direction of the State mine inspectors.

At present only one State has recognized this need. Ohio, in its coal-mining codes, requires that the chief inspector, also the district inspectors, shall have knowledge of the uses and dangers of electricity. Colorado requires the commissioner to investigate, report, and record the advancement made in the application of electricity. The Ohio rule (see Table 5) follows:

> Qualifications of district inspectors of mines: No person shall be appointed district inspector of mines unless he has been a resident of the district for which he is appointed for at least two years; has had at least five years' actual practical experience in mining in this State; has a practical knowledge of the best methods of working and ventilating mines, of the nature and properties of noxious and poisonous gases, particularly firedamp, of the best means of detecting the presence of and preventing accumulation of such gases, and the best means of removing the same; and has a practical knowledge of the uses and dangers of electricity as applied at, in, and around mines.

This regulation primarily refers to the qualification of mine inspectors, but is quoted here in order to give due credit to the several States for every regulation bearing in any way on the use of electricity in coal mines.

RULES OF CLASS II.

NATURE AND PURPOSE.

The rules of Class II govern the design, installation, operation, and maintenance of electrical apparatus installed underground. The electrician and the company electrical inspector should be guided by the detailed instructions and the State inspectors aided in determining whether proper precautions have been taken.

The rules for stationary apparatus are different from those for portable equipment, and for apparatus used in gaseous sections of a mine from those for apparatus used only in nongaseous mines or in nongaseous sections.

Class II has been subdivided under 20 headings and a table arranged to show how far the different States have progressed in formulating specific rules relating to electrical apparatus. State codes having any distinct reference to a given subdivision have been credited with a rule, although the rule may be inadequate. The different States have been rated on the basis of the number of subdivisions covered by each State.

TABLE 2.—*States having rules of Class II, those relating to the design, installation, operation, and maintenance of undeground electrical apparatus.*

States.	For apparatus in general.	For underground stations.	For switchboards and switchboard accessories.	For motors,[1] stationary, when used in nongaseous sections of a mine.	For motors, portable, when used in nongaseous sections of a mine.	For locomotives, when used in nongaseous sections of a mine.	For transformers, when used in nongaseous sections of a mine.	For switches, when used in nongaseous sections of a mine.	For protective devices, when used in nongaseous sections of a mine.	For lamps, when used in nongaseous sections of a mine.	For blasting units, approved or permissible for use in nongaseous sections of a mine.	For signaling apparatus, when used in nongaseous sections.	For telephones.	For motors, stationary, approved or permissible for use in gaseous sections of a mine.	For motors, portable, approved or permissible for use in gaseous sections of a mine.	For locomotives, approved or permissible for use in gaseous sections of a mine.	For switches, approved or permissible for use in gaseous sections of a mine.	For protective devices, approved or permissible for use in gaseous mines.	For lamps, approved or permissible for use in gaseous sections of a mine.	For blasting units, approved or permissible for use in gaseous sections of a mine.	Rating.
Alabama					(2)			[3] Yes.		[4] Yes.		[5] Yes.									15
California	Yes.	[6] Yes	Yes.	[7] Yes.			[7] Yes.	Yes.	Yes.	Yes.	[8] Yes.	(9)	Yes.	[7] Yes.	[7] Yes.						60
Colorado		(10)										Yes.									5
Idaho												Yes.									5
Illinois											(11)	(9, 12)	Yes.						Yes.		10
Indiana										(13)		(9)									0
Iowa												(9)	Yes.								5
Kansas												(12)	Yes.								5
Kentucky													(13)						Yes.		5
Missouri										(13)											0
Montana					[15] Yes.	[16] Yes.				(14)		(13)	Yes.								15
New Mexico										Yes.	[17] Yes.		Yes.							[17] Yes.	15
North Dakota					[15] Yes.	[16] Yes.						Yes.	Yes.								20
Ohio					[15, 18] Yes.	[19] Yes.		Yes.	Yes.	Yes.	(11)	Yes.									30
Oklahoma		[20] Yes.		[21] Yes.	(22)							(9)	Yes.								15
Pennsylvania (bituminous)	Yes.	[6] Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	[8] Yes.	Yes.	Yes.	Yes.	[8] Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	100
Pennyslvania (anthracite)											(23)										0
Tennessee													Yes.								5
Texas												(9)	Yes.								5
Washington	Yes.	[6] Yes.	Yes.	[7] Yes.	Yes.	[24] Yes.	Yes.	Yes.	Yes.	Yes.	[8] Yes.	Yes.	Yes.	Yes.	[25] Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	100
West Virginia					Yes.			(26)							Yes.	Yes.			Yes.		20
Wyoming													Yes.								5

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[1] Motors are taken to include all motors in use underground except those on locomotives.
[2] Forbids use of portable apparatus of higher than medium voltage.
[3] Specifies voltage above which oil switches must be used.
[4] Forbids use of certain types of lamps.
[5] Refers to location of wires of such circuits.

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[6] Refers to stations containing switchboards and to transformer rooms.

[7] Refers to installation of protective devices for such equipment.

[8] Does not specify that approved or permissible equipment must be used.

[9] Signals are mentioned, but electric signals are not mentioned specifically, nor are there regulations for the use of electric systems.

[10] Forbids unauthorized entry into underground stations.

[11] Requires electric battery shot firing in sinking shafts. Has no regulations for the use thereof.

[12] Refers to signals given by telephone, and there is also some reference to signal systems but not specifically to electric systems.

[13] Reference is indirect and no provision is made for regulation.

[14] May use incandescent lights in barns.

[15] Refers to instructions to operators and details method of procedure to be followed in making connection to power supply.

[16] Refers to instructions to drivers, motormen, and trip riders.

[17] Optional to use approved equipment or employ shot firers in all but anthracite mines, to which the regulation does not apply.

[18] Refers to voltage restrictions.

[19] Restrictions in operation.

[20] Refers to pumping stations.

[21] Refers to pumps.

[22] Operating regulation, no reference to electrical operation.

[23] Merely specifies electricity shall be used in firing shots in sinking shafts. Provides no rules or regulations.

[24] Trolley locomotives must not be operated at higher than medium voltage.

[25] Requires that all motors, with their auxiliary devices, be provided with explosion-proof inclosures.

[26] Switches must be placed at important points in a mine.

Table 2 shows that the codes of 19 States cover one or more of the subdivisions. Pennsylvania (bituminous) and Washington have given by far the most consideration to the enactment of rules relating to underground electrical apparatus. Besides these 19 States, there are 11 other coal mining States that have not provided rules of this kind. Three State codes, Missouri, Indiana, and Pennsylvania (anthracite) make indirect reference to lamps, signaling apparatus, and blasting units, respectively, but these references can not be considered as rules that regulate the use of electrical apparatus.

DISCUSSION OF THE RULES OF CLASS II.

Each of the subdivisions already considered under class II will be discussed briefly with respect to the purpose of the rule, and, so far as possible, examples of existing rules or regulations will be given.

GENERAL RULES FOR UNDERGROUND ELECTRICAL APPARATUS.

The rules belonging to this subdivision are those of such a general nature that they apply to all underground electrical apparatus, and therefore can not be classified readily under specific headings without numerous repetitions. They deal with the protection and general suitability of the equipment for use in this class of service.

The requirements for general ruggedness of design and special insulation to withstand the severe conditions of mine service have not yet been specified by any State. Only three State codes—California, Pennsylvania (bituminous), and Washington—have any of the above-mentioned requirements. California's code (see Table 5) covers the protection of apparatus in the following rule:

> SECTION 67. *a.* Every stationary motor and every portable motor underground, together with its starting device, shall be protected by a fuse on each phase, or (in the case of motors of more than 40 horsepower) by a circuit-breaking device on at least one phase of direct current motors and on each phase of alternating current motors, and by switches arranged to cut off entirely the power from the motor The above devices shall be installed in a convenient position near the motor and in sight of it.

RULES FOR UNDERGROUND STATIONS.

Underground stations are the living quarters of permanent electrical installations, and contain switchboards, pumps, hoists, battery-charging outfits, transformers, miscellaneous motors, motor generators, and substation equipment. Upon the location, construction, and general suitability of the station depends partly the life of the equipment installed in it.

A properly planned underground station should be large enough to permit a suitable arrangement of the electrical equipment, since accidents often are caused by a lack of space about the equipment. The stations should be of fireproof construction throughout, well lighted and well ventilated, and as dry as conditions permit. Electrical machinery is expensive and proper housing pays.

No State rules make complete provision for the design, construction, inspection, and maintenance of underground stations. The codes of California (see Table 5), Pennsylvania (bituminous), and Washington have headings, "Underground Stations," but most of the provisions listed under them refer to the installation of equipment in the stations rather than to the stations themselves. California and Pennsylvania (bituminous) rules provide for transformer-room construction only. Washington has no reference to underground station construction. Oklahoma's law provides for pump houses. The following quotations contain the State regulations on this subject:

The Pennsylvania (bituminous) and California codes (see Table 5) require that:

> Transformer rooms shall be properly lighted, shall be of fireproof construction, and if of conductive material shall be effectively grounded.

The Oklahoma code (see Table 5) says:

> All electric pumps inside of the mines shall receive careful attention while in use at a permanent pumping station; such pumps shall be placed in a fireproof shed, constructed of masonry walls.

FOR SWITCHBOARDS AND SWITCHBOARD ACCESSORIES.

Switchboards are structures upon which are mounted the switches, rheostats, fuses, circuit breakers, meters of various types, and other auxiliary electrical equipment. Because such auxiliary equipment needs protection from mechanical injury and from moisture and dust, care should be taken that the roof is well supported and that the equipment is kept free as possible from moisture and dust. Ample room should be left in front of the board to permit free passage and to allow switches and other equipment to be operated. Likewise, there should be plenty of room at the back of all switchboards, in order that oil switches may be inspected or wiring changes made. This space should not be used for storage of clothes or other material.

In order that equipment on the boards shall be operated satisfactorily the framework of the switchboard must be rigid and strong. Structural steel or pipe is generally used for supporting the panels. Switchboard panels should be of nonabsorbent insulating material. Where the equipment or instrument is insulated in itself, with insulating qualities equal to that of the panels, it can be mounted directly on the framework.

The space behind high-voltage switchboards should be fenced to prevent anyone coming into contact with live parts.

Three States—California, Pennsylvania (bituminous), and Washington—have rules in their codes to cover switchboards. The rule from California's code (see Table 5) follows:

> Main and distribution switch and fuse boards shall be made of noncombustible, nonabsorbent, insulating material, which shall be free from metallic veins. The board shall be mounted upon supporting frameworks of iron or steel and fixed in a dry place. If insulated conductors are used in the wiring of the board, the insulation of such conductors shall be flameproof. * * *
>
> *Passageways.*—A passageway not less than 3 feet in width shall be maintained in front of all switchboards, and behind all switchboards more than 30 inches wide, installed underground, after these rules go into effect: *Provided, however*, That in the case of high-voltage boards, such passageways shall not be less than 4 feet in width. In cases of old installations which do not meet the requirements of this paragraph, no one shall be permitted back of the switchboards while the current is on.
>
> *Space back of switchboards.*—The space at the back of switchboards, over 30 inches wide, shall be accessible from each end, and shall be kept locked up in case of high-voltage boards; but no lock shall be used that will not permit the door being opened from the inside without the use of a key. In no case shall this space be used as a change room, wardrobe, or for the storage of material. Noncombustible flooring only shall be used at the front and back of high-voltage boards, and insulating mats or their equivalent shall be provided in front and back of all boards, whatever the voltage.
>
> *Conductors crossing passageway.*—No electric conductor shall cross a passageway at the back of a switchboard except below the floor, or at a height of not less than 7 feet above the level of the floor.

FOR MOTORS; STATIONARY, WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

Rules governing the use of electric motors in underground mines should prescribe that they be designed for exceptionally severe service and as far as possible be protected from moisture or dust. As favorable locations as possible for installing the motors should be chosen—that is, a room should be selected that has a good roof, is dry, and is sheltered from dust and dirt. The motor should be installed on permanent, solid foundations. Auxiliary equipment used in the operation of the motor, such as switches, fuses, and rheostats, should be mounted on a switchboard and the wiring between this equipment and the motor properly installed. The regulating equipment should be arranged to disconnect the motor completely from the circuit. The frames of the motors and of their control equipment should be effectually grounded.

Every motor should be protected from short circuits by fuses, circuit breakers, or by both. In the case of grounded circuits this protection is needed on but one side of the line, but in alternating-current installations the protection should be placed in at least two phases. Circuit breakers should be used with motors developing over 50 horsepower, and, in addition, motors larger than 50 horsepower should have a voltmeter. In case of alternating-current installations this voltmeter should, by some convenient arrangement, be

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capable of showing the voltage on all phases. Motors larger than 50 horsepower should be provided also with a suitable ammeter for measuring the current on the motor.

California, Oklahoma, Pennsylvania (bituminous), and Washington codes have partly covered this subject. The following example from the Pennsylvania (bituminous) code (see Table 5) is the most complete:

> Every stationary motor underground, together with its starting resistance, shall be protected by a fuse on each pole or circuit-breaking device on at least one pole for direct current, and two poles for alternating-current motors, and by switches arranged to entirely cut off the power from the motor. The above devices shall be installed in a convenient position near the motor, and every stationary underground motor of 100-brake horsepower or over shall be provided with a suitable meter to indicate the load on the machine.

Besides this, the Pennsylvania (bituminous) code includes a general rule, regulating the capacity of all apparatus, which applies to motors.

FOR MOTORS; STATIONARY, APPROVED OR PERMISSIBLE, FOR USE IN GASEOUS SECTIONS OF A MINE.

If stationary motors are used in gaseous sections of a mine, the motor and all accessory parts should be of an approved or permissible type, as open or unprotected types of equipment are a menace to the mine from their liability to ignite gaseous mixtures through the sparking of electrical parts. By ''approved'' is meant equipment admitted to the approved list of a State department of mines. In order for equipment to be admitted to such a list it should be tested by a disinterested committee designated by the State department of mines. This body should be qualified by practical and technical knowledge and should be equipped with the proper facilities for the conduct of such tests. By ''permissible'' is meant equipment listed by the Bureau of Mines as suitable for use in gaseous and dusty mine atmospheres.

California, Pennsylvania (bituminous), and Washington codes make provisions of different degrees of completeness. This rule from the Pennsylvania (bituminous) Code (see Table 5) is illustrative:

> In any gaseous portion of a mine all motors, unless placed in such rooms as are separately ventilated with intake air, shall have all their current-carrying parts, also their starters, terminals, and connections, completely inclosed in explosion-proof inclosures made of noninflammable material. These inclosures shall not be opened except by an authorized person, and then only when the power is switched off. The power shall not be switched on while the inclosures are open. * * *
>
> All inclosed motors used underground shall be opened and thoroughly inspected by the person in charge of electrical equipment, or his assistant, at least once a week, and, where necessary, shall then be cleaned and repaired. * * *

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MOTORS, PORTABLE, WHEN USED IN NONGASEOUS MINES.

Portable motors are subject to greater strain and more severe service than stationary motors, and therefore must be designed with extreme ruggedness. The auxiliary parts, such as controller, fuses, switches, and rheostats, must be moved about with the equipment and should be securely mounted on the same foundation as the motor. Portable motors are generally provided with several hundred feet of cable to permit connection to the power circuit. These cables when used with coal-cutting equipment are provided with a reel for running out the cable the desired length. Such cables are termed "trailing cables." Suitable provision should be made at or near the motor for entirely disconnecting the cables from the motor. Trailing cables should be thoroughly insulated, especially at the points where they are clamped to the machine frame and where they pass through the casing walls. Careful attention also should be given to the means used to attach the cables to the motor to avoid short bends or abrasion of the cable and to relieve mechanical strain at the points where the wires are attached. The other end of the trailing cable should be provided with means of properly attaching the wires to feeder circuits without danger of electric shock to the person making the connection.

Trailing cables should be regularly inspected for bare spots, and when found in need of repair should be removed to the surface, thoroughly dried out, and repaired. An extra cable should be kept on hand with which to replace a cable as soon as the insulation becomes defective.

Several State codes mention portable equipment, but none has adequate provision governing their use. The Montana code requires an examination of the roof before starting mining machines, and specifies rules for precautions to be observed while operating them. It also details the method of procedure in attaching and detaching the cables to the power supply. The Ohio rules restrict the voltage of portable equipment to 325 volts as shown at the nearest switchboard. The Pennsylvania (bituminous) Code (see Table 5) refers more particularly to trailing cables, as follows:

> Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with extra stout braiding, hose pipes, or other equally effective covering. Each trailing cable in use shall be daily examined by the machine operator for abrasions and other defects, and he shall also be required to carefully observe the trailing cable while in use, and shall at once report any defect to the person in charge of electrical equipment. In the event of the trailing cable in service breaking down or becoming damaged in any way, or of its inflicting a shock upon any person, it shall at once be put out of service. The faulty cable shall not again be used until it has been repaired and tested by a properly authorized person. The trailing cable shall be divided at the motor, but only for such length as is necessary for making connection

to the motor, and the cable, with its outer covering complete, shall be securely clamped to the motor frame in such a manner as to protect the cable from injury and to prevent any mechanical strain being borne by the single ends that make electrical connection to the motor.

* * * The person in charge of a coal cutter or drilling machine shall not leave the machine while it is working, and shall, before leaving the working place, see that the current is shut off from the trailing cables.

MOTORS, PORTABLE, APPROVED OR PERMISSIBLE, FOR USE IN GASEOUS MINES.

Special care should be exercised in the selection of equipment that is moved from place to place and is frequently called upon to operate at the working face—the most dangerous place in the mine.

Portable motors for use in gaseous sections of a mine must be safeguarded to prevent shock to those using them, and in addition must be designed to eliminate the danger of ignition of gas or coal dust through arcing or sparking. For this reason only approved or permissible types should be used in gaseous sections of a mine. (See "Stationary Motors, Approved or Permissible.") Only one State (West Virginia) has enacted rules requiring approved portable equipment for use in gaseous sections of a mine. This rule (see Table 5), which refers to coal-cutting equipment only, is as follows:

Within six months after this act becomes a law all electric coal-cutting machines used in gaseous portions of the mines shall be flame proof and be approved by the department of mines. No man shall be placed in charge of a coal-cutting machine in any gaseous portion of a mine who is not a competent person, capable of determining the safety of the roof and the sides of the working places, and detecting the presence of an explosive gas.

In any gaseous portion of a mine a coal-cutting machine shall not be brought within the last break-through next the working face until the machine men shall have made an inspection for gas in the place where the machine is to work, unless such examination is then made by some other competent person authorized or appointed for that purpose by the mine foreman. If any explosive gas is found in the place the machine shall not be taken in until the gas is removed.

In working places where gas is likely to be encountered a safety lamp or other suitable apparatus for the detection of fire damp shall be provided for use with machine when working, and should any indication of fire damp appear on the flame of the safety lamp, or other apparatus used for the detection of fire damp, the person in charge shall immediately stop the machine, cut off the current at the nearest switch, and report the matter to the mine foreman or fire boss, and the machine shall not again be started in such place until the mine foreman, fire boss, or a person duly authorized by either has examined it and pronounced it safe.

No coal-cutting machine shall be continued in operation in a gaseous portion of a mine for a longer period than half an hour without an examination as above described being made for gas; and if gas is found, the current shall at once be switched off the machine, and the trailing cable shall forthwith be disconnected from the power supply.

LOCOMOTIVES: WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

Trolley locomotives, gathering locomotives, operating either from the trolley or from a trailing cable, storage-battery locomotive, and combination storage battery and trolley locomotives, all come under the subdivision relating to locomotives for use in nongaseous sections of a mine.

The wiring of locomotives should be heavily insulated with a good grade of rubber, and, where practicable, the wires should be bunched, thoroughly wrapped with canvas or tape, and clamped to the frame of the locomotive. If this is done the wiring will last much longer and there will be less chance of bare spots that might cause shocks or burnouts. If it becomes necessary to dismantle the wrapped cable to make repairs, the wrapping should be carefully replaced as soon as the repairs are completed. Trailing cables of gathering locomotives should be flexible and insulated with a good grade of rubber. Thorough inspection of the cables should be made regularly. As soon as a cable is worn enough to offer an electric shock hazard, it should be replaced. Extra cables should be kept on hand to replace cables whose insulation has become defective.

Locomotives should be provided with a headlight at each end so placed and guarded as to be protected from injury by cars or falling coal. In many of the types in general use the design of the bumper guards does not offer headlights and controller enough protection from climbing of the cars.

The headlight circuit should be fused and the wiring adequately protected.

No State code contains adequate rules for the installation, operation, and maintenance of locomotives, although the subject is mentioned in the rules of Montana, North Dakota, Ohio, Pennsylvania (bituminous), and Washington.

The following extract is from the North Dakota code (see Table 5):

> Motormen and trip riders shall use care in handling the motors and cars, and shall see that signals or markers, as provided for, are used as provided, and shall be governed by the speed provided for in this act in handling cars. They shall not run the motors with the trolley ahead of the motors, except in case where they can not do the alternative, and then only at a speed of 2 miles an hour. They shall warn persons forbidden to ride on the motors or cars, and shall not permit such persons to ride on motors or cars contrary to the provisions of this act. Drivers shall use care in handling cars, especially when going down extreme grades and at junction points.

LOCOMOTIVES, APPROVED OR PERMISSIBLE, FOR USE IN GASEOUS SECTIONS OF A MINE.

In some respects the storage-battery locomotives is safer than the trolley locomotive, as the trolley wire is doubly dangerous, because of possible electric shock by contact, and by possible gas or dust ignition from sparking at the trolley wheel. The older types of storage-battery locomotives are not safe for use in gaseous sections of a mine because there may be electric sparks or flashes from the controller and commutator under normal operation, and because the wiring, the rheostat, the headlight, or the storage battery may develop defects causing dangerous sparks or flashes. Regulation, therefore, should be included in coal-mining electrical codes prohibiting any but approved or permissible locomotives in gaseous sections of a mine. (See "Stationary Motors, Approved or Permissible.")

Pennsylvania (bituminous) and Washingron codes forbid the use of trolley locomotives in any gaseous portion of a mine except on the intake air, and permit the use of storage-battery locomotives only when all electrical parts, including the battery cells, are inclosed in flame and explosion proof casings.

No practical method has been developed of inclosing the batteries of storage-battery locomotives to meet a strict interpretation of these laws; it is believed the laws should be modified to permit the use on a locomotive of storage batteries when installed in properly ventilated and locked compartments.

TRANSFORMERS, WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

The chief loss in the transmission of electrical energy consists of the product of two factors, the resistance of the wire and the current transmitted through it. For transmitting a given amount of energy the higher the voltage the smaller will be the current flowing. With allowance for a reasonable percentage loss of energy in transmission, the use of high-voltage transmission permits the use of a much smaller wire without a resultant excessive drop in voltage. Alternating current can be transmitted at a high voltage and then efficiently transformed to the desired low voltage by means of a transformer which has no moving parts. Direct current can not be transformed in this manner without the use of moving machinery, and therefore entails a greater outlay in copper wire. For this reason alternating current is being used more widely in mining operations, and the problem of the proper installation of transformers underground demands careful consideration.

In nongaseous mines it is possible to install transformers at almost any place, but in gaseous mines transformers should always be installed on a current of fresh air that has not passed through abandoned workings or become contaminated by gas from new workings.

Transformers should be installed in fireproof rooms and mounted on substantial fireproof bases or walls. Transformer casings should be mechanically strong and properly grounded. The covers should fit closely enough to prevent dirt from entering the transformer.

The leads should be properly bushed and insulated for the voltages used. Transformers should be provided with ready means of disconnecting the incoming or high side. Meters should be placed in either the primary or secondary circuits of transformers that are over 50 kilovolt amperes capacity, or means provided for connecting portable instruments into such circuits.

No State codes have adequate provisions for transformers under the conditions that obtain in modern practice. Transformers are mentioned in the codes of three States—California, Pennsylvania (bituminous), and Washington. The California code refers only to protective devices installed with transformers.

SWITCHES, WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

Mine service is particularly severe on switches; therefore all switches for underground use should be of rugged construction and generously proportioned as to capacity. Switches operating on circuits of over 125 volts should be provided with quick-break attachments to prevent excessive arcing. Where, because of moisture, there is a likelihood of switch handles becoming electrically charged, special switches operated with short wooden handles should be provided. Where an accident might result from closing an open switch, means should be provided for locking the switch in the open position. Switches should never be installed in a position where they could fall shut or close of their own weight.

Oil switches should be used for opening circuits above medium voltage or for circuits or equipment larger than 50 horsepower, except in the case of autostarters. Air-break switches, used as disconnecting switches, should not under any circumstances be used to open circuits under load. For safety the switches should be conveniently placed and accessible, yet so safeguarded that the liability to accidental contact with live parts would be reduced to a minimum. Regulations or rules for this equipment are found in the codes of six States, Alabama, California, Ohio, Pennsylvania (bituminous), Washington, and West Virginia, though not all these State codes have provisions of the same degree of completeness. The Washington rules (see Table 5) are given as an example of the type of regulations adopted:

Underground stations and transformer rooms: switchboards.—All switches, circuit breakers, rheostats, fuses, and instruments used in connection with underground motor generators, rotary converters, high-voltage motors, transformers, and low and medium voltage motors of more than 50 horsepower capacity, shall be installed upon a suitable switchboard or its equivalent. Similar equipment, for low and medium voltage motors of 50 horsepower and less, may be separately installed if mounted upon insulating bases of slate or equivalent insulating material.

Main circuits.—Every main circuit coming from generating or transformer stations shall there be provided with switches, fuses, or circuit breakers.

Bases.—All switches, circuit breakers, and fuses shall have incombustible bases.

Switches.—All points at which a circuit, other than a signal circuit, has to be made or broken shall be provided with proper switches. The use of hooks or other makeshifts is prohibited, except that connection for gathering locomotives, or locomotives and machines used in driving headings or rooms, may be made to the trolley by means of suitable hooks; switches shall be so installed that they can not be closed by gravity. * * *

SWITCHES, APPROVED OR PERMISSIBLE, FOR USE IN GASEOUS SECTIONS OF A MINE.

The liability of an arc or a flash when opening or closing an electric switch is recognized by everyone familiar with the operation of switches; therefore there should be a provision requiring the use of approved or permissible switches in the gaseous sections of a mine. Washington and Pennsylvania (bituminous) codes have provisions concerning the use of switches in gaseous sections of a mine. The extract following is from the Washington State code (see Table 5):

In gaseous portions of a mine a fixed terminal box shall be provided at the points where trailing cables are attached to the power supply. This terminal box shall be flame proof and shall contain a switch and fuse on each pole of the circuit. The switch shall be so arranged that it can be operated only from without the box when the latter is completly closed, and the switch shall also be so constructed that the trailing cables can not be attached or removed when the switch is closed. * * *

In any gaseous portions of a mine switches, circuit breakers, or fuses shall not be of the open type, but must be inclosed in explosion-proof castings or break under oil.

PROTECTIVE DEVICES, WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

Protective devices include circuit breakers, automatic switches, fuses, and ground detectors, the chief use of which is to protect other apparatus and electric circuits from excessive overloads, or in the case of the ground detector to indicate the presence of a ground on a circuit. All devices of this kind should be mounted on incombustible bases and protected as far as possible from mechanical injury, moisture, and coal dust.

Circuit breakers and automatic switches should have visible means of determining their current setting. Fuses should be so located and shielded that persons in the vicinity will not be burned by their operation. The code of the State of Ohio requires that circuit breakers be placed at certain points in a mine. The codes of California, Pennsylvania (bituminous), and Washington are much alike in their rules on this subject. A quotation from the Washington code (see Table 5) follows:

Switchboards.—All switches, circuit breakers, rheostats, fuses, and instruments used in connection with underground motor generators, rotary converters, high-voltage motors, transformers, and low and medium voltage motors of more than 50-horsepower capacity shall be installed upon a suitable switchboard, or its equivalent. Similar equipment, for low and medium voltage motors of 50 horsepower and less, may be separately installed if mounted upon insulating bases of slate or equivalent insulating material.

Switches, fuses, and circuit breakers.—Operation and capacity—Fuses and automatic circuit breakers shall be so constructed as effectually to interrupt the current on short circuit, or when the current through them exceeds a predetermined value.

Circuit breakers shall be adjusted to trip at from 50 per cent to 150 per cent of their normal rated capacity, and provided with an indicator which shall show at what current the circuit breaker is set to trip.

Fuses shall be stamped or marked, or shall have a label attached indicating the maximum current which they are intended to carry. Fuses shall only be adjusted or replaced by a competent person authorized by the mine foreman.

Feeder circuit breakers.—Circuit breakers used to protect feeder circuits shall be set to trip when the current exceeds by more than 50 per cent the current-carrying capacity of the feeder. In case the feeder is subjected to overloads sufficient to trip the circuit breaker, but of short duration, the circuit breaker may be equipped with a device which shall prevent its acting unless the overload persists for a longer period than 10 seconds.

Bases.—All switches, circuit breakers, and fuses shall have incombustible bases.

PROTECTIVE DEVICES, APPROVED OR PERMISSIBLE FOR USE IN GASEOUS SECTIONS OF A MINE.

The object of protective devices for electrical equipment is to open an electric circuit under conditions which necessarily produce arcs and flashes.

The types commonly used underground have not been designed for gassy mines. Gas ignition will take place should an accumulation of gas occur around the apparatus, unless the current-rupturing parts are properly inclosed and protected; therefore every electrical code should require the use of approved or permissible protective devices in gaseous sections of a mine.

Washington and Pennsylvania (bituminous) codes make similar provisions for this type of equipment. The following example is taken from the code (see Table 5) of the State of Washington:

In any gaseous portions of a mine switches, circuit breakers, or fuses shall not be of the open type, but must be inclosed in explosion-proof casings, or break under oil.

LAMPS USED IN NONGASEOUS SECTIONS OF A MINE.

Electric lamps commonly used in mines may be divided into three classes—stationary lamps, ranging from 110 to 250 volts and operated from circuits varying in voltage from 110 to 550 volts; semiportable lamps of the same type, but provided with a portable cord which permits attachment to any lamp socket and a certain freedom of movement of the lamps; and portable storage-battery lamps, carried in the hand or strapped to the body of the miner, or adapted for use on animals or for signal lights, or for use on mine cars. For safety it is necessary that only nonmetallic sockets, commonly called weatherproof, be used in underground mining operations. All semiportable lamps should be provided with guards which extend over the socket and lamp, and with insulating handles through which the leads are brought and to which the socket is fastened.

Lamps used in trip service are subjected to such hard usage that it is essential that they be especially rugged in design. It is advisable that these and any other lamps which are moved from place to place should be of a permissible type in mines where there are gassy sections. The rules and regulations of Alabama, California, New Mexico, Ohio, Pennsylvania (bituminous), and Washington provide for such lamps; Indiana's code has only indirect reference to electric lights, and New Mexico provides penalties for removal or destruction of lights. Some of the States require electric lights in certain places, but have no specific regulations as to their use. An example of the rules and regulations for lights in nongaseous sections of a mine taken from the code (see Table 5) of the State of California follows:

> Electric lights underground shall not be installed save by a competent person to be designated or appointed by the mine foreman.
>
> *Lamp sockets.*—The exterior of the sockets of all fixed incandescent lamps, installed after these rules go into effect, shall be entirely nonmetallic.
>
> *Flexible lamp cord.*—The use of flexible lamp cord for lighting connections is prohibited, except for portable incandescent lights to be used in connection with the inspection and repair of machinery and equipment, and in that case the cord shall be especially insulated and armored. Such portable lights shall be protected by a wire cage large enough to inclose both lamp and socket, and shall be provided with a handle to which the light and socket shall be firmly attached and through which the leading-in wires shall be carried.
>
> *Incandescent lamps.*—Incandescent lamps shall be so placed that they can not come into contact with combustible material, and shall be so placed that an adequate circulation of air may take place on all sides of them. * * *

LAMPS APPROVED OR PERMISSIBLE FOR USE IN GASEOUS SECTIONS OF A MINE.

Tests made by the Bureau of Mines[1] as to the danger of ignition of gas from the filaments of incandescent lamps have shown that there is sufficient heat in a glowing filament to ignite explosive mixtures of mine gas when the mixture comes in contact with the filament. This danger exists with commercial types of lamps used in stationary mine lighting and in the miniature lamp bulbs used in portable storage battery lamps. Provisions should always be made to interrupt the current in some manner at the same time the bulb glass is broken.

Electrical codes should require the use of approved or permissible lamps in gaseous sections of a mine. No State code contains adequate provisions on these subjects. Typical reference to the use

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[1] Clark, H. H., and Ilsley, L. C., Ignition of mine gases by the filaments of incandescent electric lamps. Bull. 52, Bureau of Mines, 1913, 31 pp.

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of approved or permissible lamps for duty underground is found in the Illinois State code (see Table 5), as follows:

Electric lamps which will not ignite explosive gases may be used instead of safety lamps for purposes for which safety lamps are required in the act, except for testing for explosive gas.

BLASTING UNITS APPROVED OR PERMISSIBLE FOR USE IN NONGASEOUS SECTIONS OF A MINE.

Blasting units should have ample capacity to do the work required and should be provided with safety features that will prevent premature shots. There should be a provision in the electrical code requiring the use of permissible or approved blasting units or machines in nongaseous mines. None of the State codes, except that of New Mexico, mention approved or permissible units for use in nongaseous sections of a mine. By the New Mexico code, electrical shot-firing units can not be used by any other than authorized shot firers unless such units are of an approved type. California, Pennsylvania (bituminous), and Washington have regulations concerning equipment to be used, but do not specify that such units must be approved. Units or systems not cared for specifically under Pennsylvania (bituminous) or Washington codes must be approved by the Federal Bureau of Mines.

Regulations for blasting units as found in Pennsylvania (bituminous) code (see Table 5) follow:

Only competent persons who have the necessary training and skill, and who have been properly instructed in the work, and duly authorized by the mine foreman, shall be allowed to fire shots electrically in any mine. * * *

Portable shot-firing machines, sometimes called generators, shall be inclosed in a tightly constructed case when employed in any portion of the mine. All contacts, when made or broken, shall be within the case, except that the binding posts for making connections to the firing leads may be outside.

Primary or secondary batteries used for shot firing shall be provided with a suitable case, covered by rule 91. The batteries shall be constructed so that if the wires of the detonators or leads accidentally or otherwise come in contact with the binding posts no current will be discharged. They shall be provided with a detachable handle, plug, or key, without which the current can not be closed, or provided with one or more safety-contact buttons, which are well countersunk or protected by a nonconducting housing. The plugs, handles, or keys shall be detached when not actually in use for firing a shot, and shall not, under any circumstances, pass from the personal custody of the person commissioned to fire the shots, while on duty.

All portable devices for generating or supplying electricity for shot firing, when in a mine, shall be in charge of the person commissioned to fire the shots.

No firing machine or battery shall be connected to the shot-firing leads until all other steps preparatory to the firing of a shot have been completed and all persons have moved to a place of safety, and no person other than the shot firer shall make such connection.

Immediately after the firing of a shot, the firing leads shall be disconnected from the supply or source of electricity, and no person shall approach a shot which has failed to explode until the firing leads have been so disconnected by the shot firer

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from the device and an interval of 5 minutes has elapsed since the last attempt to fire the shot.

Frequent tests shall be made of all devices covered by rule 93, to insure that their capacity has not been decreased by use or accident.

BLASTING UNITS APPROVED OR PERMISSIBLE FOR USE IN GASEOUS SECTIONS OF A MINE.

Blasting units for use in gaseous sections of a mine should not only have ample capacity to do the work required and safety features to prevent premature shots, but should also be designed to offer no electrical hazard by the ignition of possible accumulation of gas. The regulations for gaseous sections of a mine should require the use of approved or permissible blasting units that have been approved for use in gaseous mines.

No specific regulations for blasting units of a type approved or permissible for use in gaseous sections of a mine are found in any of the State codes. Pennsylvania (bituminous) and Washington codes, however, specify that units not provided for under their rules must be approved by the Federal Bureau of Mines. This makes an indirect ruling, since the units described are not necessarily of a proper type for service in gaseous sections of a mine. The code (see Table 5) of the State of Washington on the subject follows:

Special systems.—The use of special electrical shot-firing systems or equipment not covered by the foregoing shall receive the approval of the testing station of the Federal Bureau of Mines.

TELEPHONES.

Telephones in themselves offer no hazard either from electric shock or from ignition of gas. They may, however, become charged to a dangerous extent should their circuits come in contact with high-voltage circuits. Several States have required the installation of telephones underground in order that there shall be an efficient means of communication between the mine workings and the outside office in case of actual or threatened disaster. Whenever telephones are used underground, special designs adapted to mine conditions should be required. Many of the State codes require or recommend the use of telephones, but few of them are specific in their rules and regulations covering them.

The Oklahoma code (see Table 5) contains the provisions following:

After six months from the date of the approval of this act it shall be unlawful for any person, company, corporation, owner, lessee, officer, or agent to operate, or permit to be operated, any coal mine within the State of Oklahoma not equipped with party-line telephone system as hereinafter provided.

In every coal mine where as many as 15 men are engaged in digging coal there shall be a party-line telephone system, which shall include, in either shaft, slope, or drift mines, one telephone on the surface, to be located in the office occupied by the weigh boss and checkman; and in addition thereto, in slope or drift mines, there

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shall be one telephone at each lift along the slope or drift, and the same shall be placed at or in the mouth of either of the entries; and there shall be one telephone at a distance of not more than 150 feet from the face of each entry, and an additional telephone at intervals of 1,000 feet along each entry: *Provided*, That it shall not be necessary to maintain said telephones at said intervals of 1,000 feet along the worked-out portions of any entry, but only where work is being done. In shaft mines, in addition to the telephones provided for on the surface, there shall be one telephone at the bottom of the shaft not to exceed 100 feet therefrom; and in addition thereto, there shall be one telephone at each lift along the plane and main entry or slope, and the same shall be placed at or in the mouth of either of the entries, and there shall be one telephone at a distance of not more than 150 feet from the face of each entry; and an additional telephone at intervals of 1,000 feet along each entry: *Provided*, It shall not be necessary to maintain said telephone at intervals of 1,000 feet along the worked-out portions of any entry, but only where work is being done.

It shall not be necessary to retain telephones in worked out portions of any mine, but the same may be removed therefrom when work therein is discontinued.

SIGNALING APPARATUS: WHEN USED IN NONGASEOUS SECTIONS OF A MINE.

The working voltage on signaling apparatus usually does not exceed 30 volts, therefore no precautions need be taken against electric shock unless the apparatus becomes accidentally charged by a high-voltage circuit. However, as many of the operations having to do with the safety of men depend upon the proper operation of signals, it is essential that signal apparatus be selected with respect to its adaptability for mine service, that as far as possible it be placed so that it shall not be mechanically injured or subjected to moisture or dust, and that its maintenance be given careful attention.

Idaho, North Dakota, Ohio, Pennsylvania (bituminous), and Washington codes provide to some extent for signaling equipment, but they refer to the installation of signaling systems rather than to specific rules covering the signaling equipment, excepting in the cases of Pennsylvania (bituminous) and Washington codes (see Table 5), which have the following provision:

> Bells, wires, insulators, contact makers, and other apparatus used in connection with electric signaling underground, shall be of suitable design, of substantial and reliable construction, and erected in such a manner as to reduce the liability of failures or false signals to a minimum.

RULES OF CLASS III.

NATURE AND PURPOSE.

Under Class III are listed the regulations governing the installation, inspection, and maintenance of all underground electrical circuits, information relating to the proper handling of electrical circuits, including general information for the mine operator and mine official, and detailed information for the mine electrician and company inspector.

Coal-mine electrical codes should be so comprehensive that no electrical circuit used underground should be omitted from consideration, whether it be short or long, or composed of small wires or large cables, or whether installed in gaseous or in nongaseous sections of the mine. The rules should be plain and detailed to enable qualified persons to construct and maintain practical, safe, electrical circuits.

Class III has been subdivided under 17 headings and a table arranged to show how far the different States have progressed with respect to specific rules of this kind. If a State code has made any distinct reference to a given subdivision, it has been credited with a rule, although the rule may be inadequate. The different States have been rated on the basis of the number of subdivisions covered by each State.

TABLE 3.—*States having rules of Class III, those governing the installation, inspection, and maintenance of underground electrical circuits.*

States.	With respect to capacity of underground circuits.	General, for underground circuits.	For protection of underground circuits.	For protection of branch power circuits.	For feeder circuits.	For trolley circuits.	For lighting circuits.	For power and lighting circuits in gaseous mines or gaseous sections of a mine.	For telephone circuits.	For signal circuits for use in nongaseous mines.	For signal circuits for use in gaseous mines.	For permanent shot-firing circuits.	For temporary shot-firing circuits.	For high-voltage circuits.	For mechanical safeguards for power circuits.	For protection of circuits when blasting is being done.	For replacement of damaged or deteriorated circuits.	Rating.
Alabama		Yes.				(1)	(2)		Yes.	Yes.		Yes.		Yes.	Yes.			36
California		Yes.	Yes.	Yes.	Yes.	Yes.	Yes.			Yes.		[3] Yes.		Yes.	Yes.	Yes.		66
Idaho		Yes.				(4)				(5)					Yes.			12
Illinois		Yes.							Yes.	[5] Yes.					Yes.		(6)	24
Iowa									Yes.									6
Kansas									Yes.									6
Kentucky		Yes.				Yes.			Yes.	Yes.		Yes.			Yes.			36
Michigan		Yes.																6
Ohio		Yes.	Yes.	Yes.	Yes.	Yes.				[7] Yes.					Yes.			42
Oklahoma		Yes.							Yes.						Yes.	(8)		18
Pennsylvania (bituminous)	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	[9] Yes.	Yes.		Yes.	Yes.	[10] Yes.		90
Texas		Yes.				Yes.									Yes.			18
Washington		Yes.	Yes.		Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	[8] Yes.	Yes.		Yes.	Yes.			72
West Virginia		Yes.			Yes.	Yes.									Yes.			24
Wyoming		Yes.							Yes.					Yes.	Yes.			24

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[1] Prohibits installation of trolley circuits where safety lamps are used. Where trolley wire is less than 6½ feet above rail at crossing places it must be properly shielded.
[2] Forbids series lighting circuits above 600 volts direct current or 480 volts alternating current.
[3] Prohibits use of light and power circuits for shot-firing circuits except with certain restrictions.
[4] Provides for mechanical safeguards at certain places.
[5] Relates to signal circuits in shafts.
[6] Provides for telephone circuits only.
[7] States that suitable signaling systems be installed but has no specific reference to electrical systems or their installation.
[8] Protection for telephone circuits.
[9] Applies to the voltage on signal systems installed in gaseous mines.
[10] Provides for the protection of cables during blasting.

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The table "Rules Governing the Installation, Inspection, and Maintenance of Underground Electrical Circuits," shows that 15 States cover one or more of the subdivisions. Pennsylvania (bituminous), California, and Washington have again given the most consideration to the enactment of the electrical rules or regulations. There are 15 other States having coal mines that have not provided rules for the installation, inspection, and maintenance of underground electrical circuits.

DISCUSSION OF RULES OF CLASS III.

Each of the subdivisions already considered under class III will be discussed with respect to the purpose of the rule, and usually an example will be given of a rule or regulation already in force.

RULE RELATING TO CAPACITY OF ALL UNDERGROUND CIRCUITS.

The capacity of a circuit is the amount of electric current measured in amperes that the circuit is capable of transmitting without overheating the wires or their insulation. The capacity of a given size and kind of wire depends upon its insulation and the surrounding air space; a bare wire has more capacity than an insulated wire, and a circuit having the same size conductor will be able to transmit more power without overheating when in a well ventilated open space than if installed in conduit.

When circuits are called upon to work beyond their rated capacity, not only is there danger of overheating of the wires, but there is a loss of power and less efficient service to the equipment served.

A quotation from the Pennsylvania (bituminous) code (see Table 5) follows:

> The size of all conductors shall be determined with regard to the maximum amount of current which they are to carry, by reference to the table provided by the National Board of Fire Underwriters, which shows maximum current carrying capacities of copper conductors.

GENERAL RULES FOR UNDERGROUND CIRCUITS.

All underground circuits should be properly installed in a permanent manner. By proper installation is meant that the wire should be supported on insulators mechanically and electrically sufficient for the character of the load. These insulators should be placed at intervals close enough to prevent excessive sag or contact with other wires, timbers, roof, or rib. Following this practice would prevent the erection of so-called "temporary" installations which are often allowed to remain in use indefinitely.

Armored cables need not be placed on insulators, but should be well supported and protected from mechanical injury. In no case should unarmored conductors be supported other than on suitable insulators. Good judgment should be used in laying out a circuit in an underground mine in order that the expense of maintenance of these circuits be not excessive and that the circuit shall not itself be a hazard or offer a hazard to other circuits.

Thirty-eight States have rules covering general requirements with respect to underground installations. The provisions on this subject as found in the Pennsylvania (bituminous) code (see Table 5) follow:

> All underground cables and wires, other than trailing cables, unless provided with grounded metallic covering, shall be supported by means of efficient insulators.

In addition it would be well to require good mechanical construction and proper installations for all underground circuits.

PROTECTION OF UNDERGROUND CIRCUITS.

All underground circuits may become overloaded; that is, more current may be transmitted over them than the conductors are designed to carry. This may result from a fall on the lines causing a short circuit, or from the addition of electrical equipment until the current demand is beyond the capacity of the circuit. Therefore every circuit should be provided with means of preventing prolonged overloads. The devices in common use for the protection of circuits are fuses, circuit breakers, and automatic switches, which open the circuit when the current exceeds a predetermined value. As in surface circuits, each size of wire used in underground circuits should be protected with a circuit-opening device at or near the point where the size of wire is changed. Owing to the amount of territory covered, and the impracticability of constantly replacing blown fuses or resetting circuit breakers, it is possible that current settings for such devices that are large enough to allow a generous margin for overload would be practicable and yet give more protection than is afforded at present. Ground detectors are used as an aid in the protection of underground circuits and indicate grounds in the circuit through defective insulators or contact of the wires with coal, rock, or timbers.

The following quotation is from the code (see Table 5) of Pennsylvania (bituminous):

> Every main circuit coming from generating or transformer stations shall there be provided with switches, fuses, and circuit breakers. * * *
>
> All underground systems of distribution that are completely insulated from earth shall be equipped with properly installed ground detectors of suitable design. The conditions of such system as indicated by the ground detector shall be noted each day by the person in charge of the underground wiring or by another competent person, who shall immediately report to him the occurrence of a ground.

PROTECTION OF BRANCH POWER CIRCUITS.

Every branch circuit that extends more than 200 feet from a main circuit should be provided with means of cutting off the current from the branch circuits. When a circuit is not "alive" repairs or extensions can be made more efficiently and with safety. The means of attaining this end is by the use of a section insulator and switch. The insulator makes a break in the line, the current being carried to the circuit by means of the switch which is connected to the main circuit and the branch on either side of the insulator, so that opening the switch disconnects the branch from the power supply but does not interrupt service on the main circuit. Pennsylvania (bituminous) code (see Table 5) provides for this, as follows:

> Every branch circuit shall be provided, at the point where it leaves the main circuit, with a switch of not less than 100-ampere capacity, on each pole.

FEEDER CIRCUITS.

Under "feeder circuits" are included all underground feeder circuits supplying energy to electric locomotives, drills, coal-cutting equipment and other motors, including circuits in shafts, bore holes, drifts, slopes, and in the mine proper from the point where they leave the surface, including all portions of such circuits installed underground.

A rule governing the installation of feeder circuits should cover as far as possible the diverse conditions encountered in underground electrical installations. The most difficult place to install feeder circuits is probably in shafts where sulphur water may be encountered that will attack the cable armor or the clamps used in supporting the cable, or where water or ice may collect and either cause a ground at the support or at some other point where the wires touch the side of the shaft. Again, the vibration of the cages may chafe the insulation or the presence of other service lines, such as for steam or for water may leave no proper place for installing the circuits.

Whatever method is adopted the circuit should be substantially supported in such a way as to avoid undue mechanical strain on the conductors or their insulation, and the wires or cables so insulated at either the point of support or throughout their length as to prevent grounding. Lead-sheathed or armored cables if not kept clear from the sides of the shaft may break down owing to the effect of electrolysis on the covering of the cable.

Holes drilled for the special purpose of introducing electric circuits underground are frequently called bore holes. These holes should be cased with iron pipe, and made large enough to permit the installation of the feeder circuit without damage to the insulation. If the wires or cables are left free in the pipe their weight should be taken by properly placed supports, to which the wires or cables can be attached before they enter the pipe. Especial care should be taken that moisture does not get into the ends of cables or into the bore hole. Care should also be taken that the cable or wires can not rub or chafe against the side of the pipe where it enters or leaves the bore holes.

The installation of feeder circuits along haulage ways demands careful consideration. In the first place the circuit should be so laid out that it is as free as possible from liability to mechanical injury—such as from falls of rock or coal or from derailed mine cars—and excessively wet routes should be avoided. The line should be supported on a sufficient number of insulators and run as straight as conditions will permit, for installations made in this way render much easier the replacement of timbers and supports.

If part of the haulage way is used as a traveling way for men or animals, the wires should be guarded to prevent accidental contact with them.

Feeder circuits installed on slopes require the same consideration as those given for haulage ways, except greater precaution should be taken to protect the wires from possible wrecks.

Persons not familiar with the principles of electricity sometimes pay too little attention to the return conductors of circuits. A good return, whether it be through the track rail, through a return wire, or both, is just as important and has just as much effect on the proper operation of the equipment as has the positive wire. This means that tracks used for return circuits should be fishplated, bonded and cross-bonded, and that these connections should be carefully maintained; and, further, that all return wires should be inspected and maintained with the same care as positive wires. In ungrounded direct-current systems there is danger of receiving shock from both wires.

The States of California, Ohio, Pennsylvania (bituminous), Washington and West Virginia make direct reference to general protection of this kind in their mining codes, but none of them enacted a law comprehensive enough to cover all phases and conditions that might exist. Rules in the California code (see Table 5) follow:

All underground cables and wires, unless provided with grounded metallic covering, shall be supported by efficient insulators.

Cables and wires unprovided with metallic coverings shall not be fixed to walls or timbers by means of uninsulated fastenings.

All wires, except telephone, shot-firing, and signal wires shall be on the same side of the working as the trolley wire, and shall be boxed or otherwise protected when timbers or tools have to be transferred up a raise.

In all shafts the angle of inclination of which is above 45° from the horizontal, and in all hoisting shafts or manway compartments, all power and cables shall be highly insulated and substantially fixed in position. All shaft cables shall be supported on insulators that can not cause abrasion of the covering or insulation, so spaced that no part of the cable shall be under a tension greater than one-fourth of its ultimate strength. The cable shall be held in position at points between the insulators by grips or cleats that can not cause abrasion of the covering or insulation. Where the cables are not completely boxed in and protected from falling material, space shall be left between them and the side of the shaft so that they may yield and lessen a blow from falling material. This section shall not be construed to prevent the installation of efficiently insulated wires in metal conduit, to transmit power underground.

Where the cables or feed wires in main roads can not be kept at least 12 inches from any part of the mine car or locomotive, they shall be specially protected by proper guards.

Buried cables shall be continuously insulated and protected by metallic sheath, preferably lead, and where they are so located that there is a possibility of danger to the sheath by puncturing, such cables shall be further protected by armor.

TROLLEY CIRCUITS.

Trolley circuits have to meet more exacting requirements for their installation than any other circuit in a mine. They can not be supported by a regular type of insulator, but must be held by special clamps so designed as not to interfere with the trolley wheel. They can not be placed in the most convenient space in the entry, but have to follow the general alignment of the track, usually a few inches to the outside of one rail and at a given distance above it. The trolley wire supports should be placed in a way to insure good alignment of the wire with the track, especially at curves of the track. Throughout the line the supports should be frequent and the wire pulled up tightly in order that the trolley wheel may readily follow and stay on the wire, and in order that the wire or trolley wheel shall not touch the roof between supports. The regulation following is taken from the Washington code (see Table 5):

In underground roads the trolley wires shall be securely supported on hangers placed at such intervals that the sag between points of support shall not exceed 3 inches. The sag between points of support can exceed 3 inches if the height of the trolley wires above the rail is 5 feet or more and does not touch the roof when the trolley passes under.

LIGHTING CIRCUITS IN NONGASEOUS SECTIONS OF A MINE.

The voltage of underground lighting circuits is usually 110 volts alternating current or 250 to 550 volts direct current. Lights are commonly placed at the bottom of the several landings, along the roadway where the manual handling of the mine cars is necessary, at points where branch roads turn off, at points where the track curvature is excessive, at the tops of steep grades, in underground electrical rooms, and in the various rooms provided for the mine officials' use. No fixed rule can be laid down covering all these diversified uses. In general, lighting circuits, being of a smaller size of wire than power circuits, can be installed with lighter brackets and smaller insulators. Because the danger from the voltage of a small wire is as great as that from the same voltage in a large wire, the same care should be used in laying out a lighting circuit as in power circuits of the same voltage to avoid moisture and to keep the wires properly insulated by means of enough insulators suitably located and spaced. Where, as in the case of installations in a mule barn, there is especial danger of fire, the circuits should preferably be in conduit. The rule under class I prohibiting the tampering with or handling of electric equipment by unauthorized persons (see p. —), should be rigidly enforced with respect to lighting circuits.

The only States having rules that apply directly to lighting circuits are California, Pennsylvania (bituminous), and Washington. The California rule (see Table 5) makes this provision:

> Wires for all lighting circuits shall be covered with an insulation adequate for the voltage of the circuit, and, unless incased in pipes or other metallic covering, shall be strung on porcelain or glass insulators. Separate uncased wires shall be kept at least 3 inches apart, except where they enter the fittings. Metallic casings, if used, shall be efficiently grounded.

POWER AND LIGHTING CIRCUITS IN GASEOUS MINES OR GASEOUS SECTIONS OF A MINE.

In modern mining there is probably no question of more vital importance to safety than the proper use of electrical circuits in gaseous mines or in gaseous sections of a mine. If mining in gaseous sections of a mine is to be carried on efficiently, and the daily output kept up, electrical apparatus is essential. If electrical apparatus is used, there must be provided circuits through which the energy to operate it can be transmitted. The question is—how shall such circuits be installed, inspected, and maintained that they shall not offer a hazard?

In mines that are termed "gassy" a large part of the mine never has a dangerous accumulation of gas, neither does the gas content in the air currents reach a dangerous percentage, and generally the dust hazard is reduced by sprinkling or other suitable means. In these sections of a mine, properly installed power and lighting circuits offer no particular hazard and there is no reasonable argument for excluding them. On the other hand, there are mines in which the gas content remains high in spite of good ventilation, and an accumulation of gas is liable to occur on the least interruption of the ventilation, and sometimes from the outburst of a gas pocket in the coal. The presence of electric circuits in such sections of a mine offers a hazard, and they should not be permitted unless installed in conduit or armored cable so protected that damage to these circuits by falls of rock, coal, or by any other accident will be improbable. Pennsylvania (bituminous) and Washington codes are the only ones having enactments covering the use of circuits in gaseous mines.

A quotation from Washington's code (see Table 5) follows:

Medium conductors may be bare, except in gaseous portions of the mines, where they may be used only on intake air. No bare conductors shall be used in rooms, or beyond the last cut-through in intake entries.

In any gaseous mines, or gaseous portions of a mine, the electric supply shall be brought underground only through such portions of the mines as are ventilated by intake air, unless in lead-incased cables.

TELEPHONE CIRCUITS.

The proper layout and upkeep of telephone circuits in the mine affect safety, as telephones are in urgent demand at the time of an accident or disaster. In order that a telephone system shall be efficient, and to avoid grounds or crosses with other electric circuits, the circuit of such system should be installed with care. Crosses may cause a noisy line, and sometimes may cause a severe shock to persons using the telephones.

Two rules that apply here, taken from the codes (see Table 5) of Illinois and Kentucky, follow:

ILLINOIS.

Telephone lines shall be constructed in a workmanlike manner and shall be repaired promptly when necessary.

KENTUCKY.

All other wires, except telephone, shot-firing and signal wires, shall be on the same side of the road as the trolley wire.

SIGNAL CIRCUITS FOR USE IN NONGASEOUS MINES.

Signal circuits in nongaseous mines, used to operate bells, usually do not exceed 30 volts, and offer no shock hazard unless charged through accidental contact with some circuit of higher voltage. Lamp signal circuits, however, often receive their energy from a 250-volt supply and consequently may offer a shock hazard.

Signal circuits are commonly used to send signals not only for the movement of coal and supplies, but often for the haulage of men; therefore their proper operation is essential to the safe and efficient conduct of the mine. Signal circuits, whether placed in shafts, slopes, or along haulage roads, should be so installed as to be free from the liability to mechanical injury or interruption to service, and should be supported on insulators or run in conduit. Where there is danger in accidental contact, the same precautions should be taken as for power circuits. Rules found in the Washington State code (see Table 5) follow:

Electrical signaling: precautions.—All proper precautions shall be taken to prevent electrical signal and telephone wires from coming into contact with the other electric conductors, whether insulated or not.

> *Character of equipment.*—Bells, wires, insulators, contact makers, and other apparatus used in connection with electric signaling underground, shall be of suitable design, of substantial and reliable construction, and erected in such a manner as to reduce the liability of failure or false signals to a minimum.

SIGNAL CIRCUITS FOR USE IN GASEOUS MINES.

Even primary battery signal circuits used for operating bells might readily cause an ignition of gas, and signal-circuit operation from power circuits would be almost sure to cause an explosion were the wires to become short circuited and arcs or sparks to result at a point where inflammable gas had accumulated. Therefore, open wiring for signal circuits, whether insulated or not, should not be used in a gaseous section of a mine.

The only specific references to signal circuits in gaseous mines or sections of a mine are found in the Washington and Pennsylvania (bituminous) codes, and are confined to the limitation of voltage of such circuits in gaseous portions of a mine. The quotation from the Pennsylvania (bituminous) code (see Table 5) follows:

> *Maximum potential.*—In any gaseous portion of a mine the potential used for signal purposes shall not exceed 24 volts, and bare wires shall not be used for signal circuits, except in haulage roads.

RULES FOR PERMANENT SHOT-FIRING CIRCUITS.

When the shot firing is done from outside the mine the usual practice is to run a separate shot-firing circuit into the mine. The success of such a system of shot firing depends upon the ability to get the electric current to the electric fuses or detonators when wanted and to keep the current away from them at all other times. Safe service depends upon the use of wire of adequate size, free from splices, and so installed with reference to other circuits that there is no possibility of coming into contact with them.

In addition, locked switches should be used for controlling such systems to prevent unauthorized persons from throwing power on the circuit, and means should be provided for making a long break in the circuit at the point of entry to the mine to safeguard the circuit from lightning discharges. Pennsylvania (bituminous) code makes as complete provision on this hazard as any of the States. An extract from this code (see Table 5) follows:

> All other wires, except telephone, shot-firing, and signal wires, shall be on the same side of the road as the trolley wire. * * * Electricity from any grounded circuit shall not be used for firing shots. * * * When shot-firing cables or wires are used in the vicinity of power or lighting conductors, special precautions shall be taken to prevent the shot-firing cables or wire from coming in contact with the light, power, or any other circuits.

TEMPORARY SHOT-FIRING CIRCUITS.

By temporary shot-firing circuit is meant the room wires of outside shot-firing systems, and also the wires used with portable firing equipment when the shot firing is done on the inside of the mine.

Rubber-covered or weatherproof wire always should be used for these circuits. If the place is damp or wet, only rubber-covered wire should be used.

For circuits connected with outside systems, no wires smaller than No. 14 gage should be used. For circuits used with portable shot-firing units where only one shot is fired at a time, the following size of wires should give satisfactory service—No. 14 gage when not more than 600 feet of wire are used, No. 16 gage when not over 350 feet, and No. 18 gage when not over 200 feet.

No mention of this subject is found in any of the existing State codes.

HIGH-VOLTAGE CIRCUITS.

For economy it is often desirable to have high-voltage circuits enter a mine and even to extend for several hundred feet within it. If such circuits are properly installed they should offer no hazard, even though they pass through a gaseous section. By proper installation is meant installing in conduit or armored cable which is so guarded that damage of the circuit by fall of rock or coal or by any other accident is improbable. If a metallic covering is used it should be continuous throughout the length of the circuit and should be efficiently grounded. Ample provision should be made in such installations to eliminate every liability of shock.

Five States, Alabama, California, Pennsylvania (bituminous), Washington, and Wyoming, have regulations concerning high-voltage circuits in their codes. The provisions in Washington's code (see Table 5) follow:

> *Transmission circuits and conductors—Power and light circuits.*—All high-pressure wires used inside of the mines shall be on the form of insulated, lead-covered, or armored conductors, subject to insulation tests, and with carrying capacity according to the rules of the National Board of Fire Underwriters. * * *
>
> Where lead-covered or armored cable is used, the lead or armor shall be electrically continuous throughout and shall be efficiently grounded.

MECHANICAL SAFEGUARDS FOR POWER CIRCUITS.

If underground feeder and trolley circuits could be placed from 10 to 15 feet above the roadbed as in surface installations, there would be no necessity for a rule on mechanical safeguards for power circuits. The conditions in mines are such that both feeder and trolley wires must be placed along roadways that are necessarily low and in many places poorly lighted, consequently these circuits offer a hazard, especially where men have to pass frequently under them in crossing or traveling roadways. The best method of safeguarding these circuits is to place boards along one or both sides of the wires. Trolley wires need to be guarded from both sides. Some feeder circuits are so located that a single board offers ample protection. The boards should be supported by iron hooks wedged solidly in holes drilled into the roof. Armored cables or circuits run in conduit do not need this protection, provided the armor or conduit is properly grounded. Many of the States have general rules on this subject. This extract from Wyoming's code (see Table 5) is typical of the rules generally provided:

> All underground power lines installed and used for the transmission of electric power in the operation of coal mines in this State shall be so constructed and equipped with safety devices as to insure the maximum of safety to the employees in such mines. All wires, whether used as feeder lines or as trolley wires, shall be put as close to the roof as possible and shall follow the entry rib as close as practicable. At all crossovers, where men have to pass under feed wires, such feed wires shall be protected by being carried in a trench cut above the level of the roof, and where this is not practicable, they shall be properly fenced or carried in suitably constructed conduits. All main feeder wires of high voltage entering the mine which are carried along the manways or traveling ways shall be protected with a suitable fence to protect employees or others from coming in contact with them, and permanent danger signs shall be posted, warning employees of the danger.

PROTECTION OF CIRCUITS WHERE BLASTING IS BEING DONE.

If flying pieces of coal, rock, or other material resulting from a blast are likely to injure a circuit, temporary protection for the circuit should be provided. Where extensive blasting is to be done, the best practice is to remove the wires until after the blasting is completed. When no precautions are taken, broken insulators, damaged wires and slack lines often result. This damage can not always be repaired in such a way that the wires have the same neatness and safety as in their original condition. California makes provision for this subject in its code (see Table 5) as follows:

> Cables shall be temporarily protected against damage at any point where workings are being repaired or where blasting is being carried on.

REPLACEMENT OF DAMAGED OR DETERIORATED CIRCUITS.

In the interest of safety and general efficiency there should be a regulation requiring the replacement of damaged or deteriorated circuits. Replacements of a temporary nature should be discouraged and an effort made to have damaged circuits put back in their original condition.

There are many factors tending to weaken good construction, such as falls of rock or coal on the lines, strains and displacement of wires by blasting and timbering, besides the natural deterioration of both the wires and their supporting structures. A few States have regulations requiring that signal and telephone circuits be maintained in good condition, but no State has yet formulated a general requirement affecting the replacement of damaged or deteriorated circuits.

STATE REGULATIONS GOVERNING SURFACE INSTALLATIONS.

State mining codes have given very little consideration to enactments regulating the installation of electrical equipment or circuits outside of the mine. The laws of several of the States are so worded as to leave the reader in doubt whether surface conditions were included. Other codes make a few specific references to outside installations. Therefore no attempt has been made to list or make comparison of these few regulations referring to surface installations.

It is believed that an ideal code should cover surface as well as underground conditions, and should be so worded and arranged in sections that it is clear whether the rule applies to underground installations or to surface installations.

SUMMARY.

The summary following shows in tabulated form the rating of each coal-producing State with respect to enactments governing the use of electricity in coal mines, and furnishes a concise argument for the adoption of more uniform laws.

TABLE 4.—*Ratings of the several coal-producing States with respect to electrical regulations for coal mines.*

Coal-producing States.	Rating.			
	Class I, general rules.	Class II, rules of apparatus.	Class III, rules of circuits.	Combined rating for all classes.
Alabama	25	15	36	24.5
Arkansas	...	...	...	...
California	80	60	66	68.0
Colorado	10	5	...	5.0
Georgia	...	...	...	...
Idaho[1]	...	5	12	5.0
Illinois	10	10	24	14.0
Indiana	...	...	...	...
Iowa	5	5	6	5.0
Kansas	5	5	6	5.0
Kentucky	5	5	36	14.0
Maryland	...	...	...	...
Michigan	5	...	6	3.5
Missouri	...	...	...	...
Montana	5	15	...	7.0
New Mexico	5	15	...	7
North Carolina	...	...	...	...
North Dakota	5	20	...	8.5
Ohio	15	30	42	28.0
Oklahoma	...	15	18	10.5
Oregon[1]	...	...	...	...
Pennsylvania (anthracite)	...	...	...	...
Pennsylvania (bituminus)	85	100	90	91.0
South Dakota	...	...	...	...
Tennessee	...	5	...	1.5
Texas	...	5	18	7.0
Utah	5	...	...	1.5
Virginia	...	...	...	...
Washington	55	100	72	75.5
West Virginia	15	20	24	19.0
Wyoming	5	5	24	10.5

[1] No mining law.

In studying Table 4 the reader should remember that liberal credit has been given in all cases, and that deductions for incomplete rules would reduce materially the ratings given.

It is readily evident from a study of this summary that three States, Pennsylvania (bituminous), Washington, and California, have far more complete codes than the other States. Another group of seven States has covered from 10 to 28 per cent of these rules in their codes This leaves 20, or two-thirds of the States having coal-mine operations, with a rating of less than 10 per cent. Nine of these States have no regulations whatever, although several times indirect reference has been made to the use of electricity. Such a condition does not seem fair to the miner. A life in the anthracite field of Pennsylvania is surely as valuable as a life in the bituminous field; yet over 150,000 men in the anthracite field of Pennsylvania have no protection in the anthracite code through electrical regulation, in which the only reference to electrical equipment has not been revised for 35 years.

TABLE 5.—*Dates of State laws and regulations from which data for foregoing tables were taken.*

State.	Title.	Date published.	Date approved.
Alabama	Mining law of the State of Alabama	1911	Apr. 18, 1911
Arkansas	State mining laws of the State of Arkansas	1919	[1] Apr. 5, 1919
California	Mine regulations; coal mines	[2] 1917	1873–1874
California	Mine safety rules issued by the industrial accident commission of the State of California.	1918	Jan. 1, 1916
Colorado	Mining laws; Federal and State mine rules and regulations appended. Colorado Bureau of Mines, Bull. 7.	1916	Feb. 1, 1916
Georgia	No law.		
Idaho	Mining laws of the State of Idaho	1913	[1] Mar. 11, 1913
Illinois	Department of mines and minerals—general information and laws.	1919	[1] July 1, 1919
Indiana	Mining laws of Indiana	1911	[1] Mar. 6, 1911
Iowa	Revised mining laws of the State of Iowa	1915	[1] July 4, 1915
Kansas	Kansas mining laws	1918	[1] July 1, 1918
Kentucky	Mining laws of the State of Kentucky	1914	[1] Mar. 23, 1914
Maryland	Mining laws of the State of Maryland	1917	1916
Michigan	Regulating the operation of coal mines	No date.	1913
Missouri	Laws of Missouri relating to mines and mining	1913	[1] Apr. 14, 1913
Montana	Laws of Montana administered by industrial accident board.	1919	Mar. 5, 1919
New Mexico	Mining statutes of New Mexico and the United States.	1916	Mar. 7, 1916
North Carolina	Mining laws of North Carolina	1907	Dec. 1, 1906
North Dakota	Coal mining code of the State of North Dakota	1919	Feb. 25, 1919
Ohio	Mining laws of Ohio compiled by the industrial commission of Ohio.	1918	1917
Oklahoma	Mining laws of the State of Oklahoma. Chapter 125, mines and mining. Coal mining regulations.	1909 1913	[1] Feb. 18, 1909 Apr. 1, 1913
Oregon	No law.		
Pennsylvania	Bituminous mining laws of Pennsylvania	1919	[1] June 1, 1915
Pennsylvania	Anthracite mining laws of Pennsylvania	1918	[1] July 19, 1917
South Dakota	Laws pertaining to mines and mining	1919	Apr. 16, 1919
Tennessee	Mining laws of Tennessee	1915	[1] Sept. 27, 1913
Texas	Coal mining laws of Texas	No date.	[1] Sept. —, 1916
Utah	The coal mining laws of the State of Utah	1917	
Virginia	Coal mining law	No date.	Mar. 13, 1912
Washington	Coal mining laws of Washington	1917	Mar. 2, 1917
West Virginia	Mining laws of the State of West Virginia	1918	June, 1915
Wyoming	Coal mining laws of the State of Wyoming	1919	[1] 1919
U. S. Bureau of Mines	Technical Paper 138	1916	

[1] Date of last amendment.

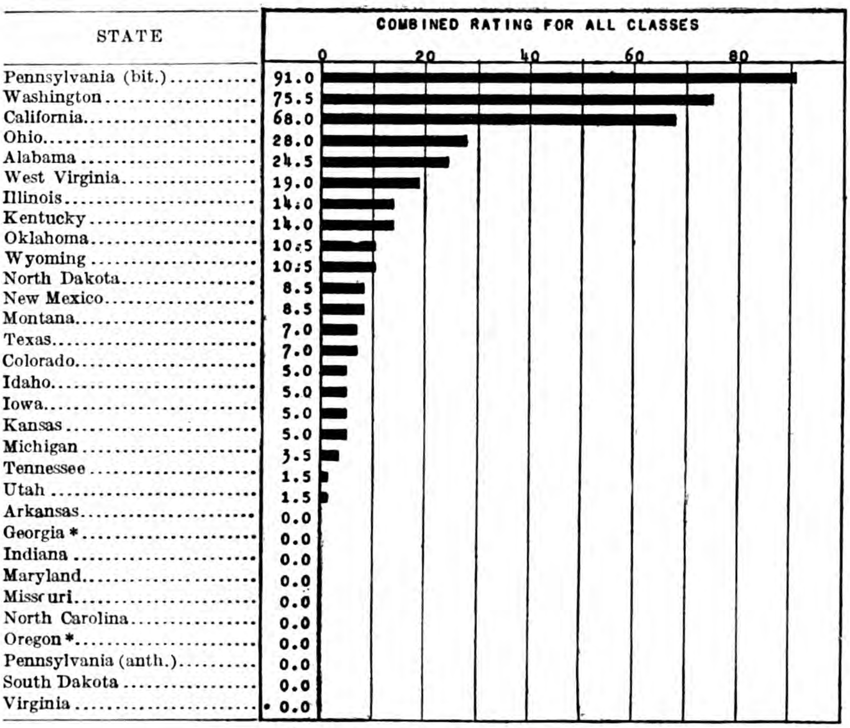
[2] California State Mining Bureau Bull. 75, Mining laws, United States and California. 1917.

If unguarded trolley lines are a hazard and need regulations in the State of Washington, they are equally dangerous in Kansas and 17 other States.

If rules requiring the posting of notices on resuscitation add to the safety of underground workers in California and the Pennsylvania (bituminous) region, why are not such notices necessary in the other 28 States?

In other words, human life being the same, and electrical hazards the same for all States, a code that is necessary in the interests of safety for the protection of the miner in one State is just as essential in every other State.

In making comparisons the chief object has been to stimulate States having no codes or inferior regulations to new efforts. By reference to quotations of laws already in force, those wishing to make a change will be able to obtain suggestions from enactments that already have been tested. Finally, it is hoped that this paper will aid in bringing about greater uniformity in electrical regulations for coal mines and in placing safety standards on a higher level.



* NO MINING LAWS.

FIGURE 1.—Rating of coal-producing States with respect to electrical regulations for coal mines.

The ordinary rules for underground electrical installations have been divided into 57 subdivisions. The above percentages represent the proportion of these subdivisions that have been adopted by the several States and included in their mining codes.

PUBLICATIONS DEALING WITH THE USE OF ELECTRICITY IN COAL MINING.

A limited supply of the following publications of the Bureau of Mines has been printed and is available for free distribution until the edition is exhausted. Requests for all publications can not be granted, and to insure equitable distribution applicants are requested to limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the director, Bureau of Mines.

The Bureau of Mines issues a list showing all its publications available for free distribution as well as those obtainable only from the Superintendent of Documents, Government Printing Office, on payment of the price of printing. Interested persons should apply to the director, Bureau of Mines, for a copy of the latest list.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

Bulletin 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 1911. 61 pp., 10 pls., 12 figs.

Bulletin 46. An investigation of explosion-proof mine motors, by H. H. Clark. 1912. 44 pp., 6 pls., 14 figs.

Bulletin 52. Ignition of mine gases by the filaments of incandescent electric lamps, by H. H. Clark and L. C. Ilsley. 1913. 31 pp., 6 pls., 2 figs.

Bulletin 68. Electric switches for use in gaseous mines, by H. H. Clark and R. W. Crocker. 1913. 40 pp., 6 pls.

Bulletin 78. Approved coal-cutting equipment, by L. C. Ilsley and E. J. Gleim, 1919, 53 pp.

Bulletin 90. Abstracts of current decisions on mines and mining, December, 1913, to September, 1914, by J. W. Thompson. 1915. 176 pp.

Bulletin 101. Abstracts of current decisions on mines and mining, October, 1914, to April, 1915, by J. W. Thompson. 1915. 138 pp.

Bulletin 118. Abstracts of current decisions on mines and mining, reported from October to December, 1915, by J. W. Thompson. 1916. 74 pp.

Bulletin 126. Abstracts of current decisions on mines and mining, reported from January to April, 1916, by J. W. Thompson. 1916. 90 pp.

Bulletin 131. Approved electric lamps for miners, by H. H. Clark and L. C. Ilsley. 1917. 59 pp., 17 pls., 7 figs.

Bulletin 137. The use of permissible explosives in the coal mines of Illinois, by J. R. Fleming and J. W. Koster. 1917. 110 pp., 8 pls., 17 figs.

Technical Paper 19. The factor of safety in mine electric installations, by H. H. Clark. 1912. 14 pp.

Technical Paper 21. The prevention of mine explosions, report and recommendations, by Victor Watteyne, Carl Meissner, and Arthur Desborough. 1912. 12 pp.

Technical Paper 23. Ignition of mine gas by miniature electric lamps with tungsten filaments, by H. H. Clark. 1912. 5 pp.

Technical Paper 28. Ignition of mine gas by standard incandescent lamps, by H. H. Clark. 1912. 6 pp.

Technical Paper 44. Safety electric switches for mines, by H. H. Clark. 1913. 8 pp.

Technical Paper 75. Permissible electric lamps for miners, by H. H. Clark. 1914. 21 pp., 3 figs.

Technical Paper 84. Methods of preventing and limiting explosions in coal mines, by G. S. Rice and L. M. Jones. 1915. 50 pp., 14 pls., 5 figs.

Technical Paper 103. Organizing and conducting safety work in mines, by H. M. Wilson and J. R. Fleming. 1917. 57 pp., 35 figs.

Technical Paper 108. Shot firing in coal mines by electricity controlled from the outside, by H. H. Clark, N. V. Breth, and C. M. Means. 1915. 36 pp.

Technical Paper 138. Suggested safety rules for installing and using electrical equipment in bituminous coal mines, by H. H. Clark and C. M. Means. 1917. 36 pp.

Miners' Circular 5. Electrical accidents in mines, their causes and prevention, by H. H. Clark, W. D. Roberts, L. C. Ilsley, and H. F. Randolph. 1911. 10 pp., 3 pls.

Miners' Circular 7. Use and misuse of explosives in coal mining, by J. J. Rutledge, with a preface by J. A. Holmes. 1913. 52 pp., 8 figs.

Miners' Circular 21. What a miner can do to prevent explosions of gas and of coal dust, by G. S. Rice. 1915. 24 pp.

PUBLICATIONS THAT MAY BE OBTAINED ONLY THROUGH THE SUPERINTENDENT OF DOCUMENTS.

Bulletin 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls., 4 figs. 10 cents.

Bulletin 61. Abstracts of current decisions on mines and mining, October, 1912, to March, 1913, by J. W. Thompson. 1913. 82 pp. 10 cents.

Bulletin 79. Abstracts of current decisions on mines and mining, March to December, 1913, by J. W. Thompson. 1914. 140 pp. 20 cents.

Bulletin 82. International conference of mine experiment stations, Pittsburgh, Pa., September 14–21, 1912, compiled by G. S. Rice. 1914. 99 pp. 15 cents.

Bulletin 113. Abstracts of current decisions on mines and mining, reported from May to September, 1915, by J. W. Thompson. 1916. 124 pp. 15 cents.

Bulletin 143. Abstracts of current decisions on mines and mining, reported from May to August, 1916, by J. W. Thompson. 1916. 72 pp. 10 cents.

Bulletin 147. Abstracts of current decisions on mines and mining, reported from September to December, 1916, by J. W. Thompson. 1917. 84 pp. 10 cents.

Bulletin 152. Abstracts of current decisions on mines and mining, reported from January to April, 1917, by J. W. Thompson. 1917. 79 pp. 10 cents.

Bulletin 159. Abstracts of current decisions on mines and mining, reported from May to August, 1917, by J. W. Thompson. 1917. 111 pp. 15 cents.

Technical Paper 24. Mine fires, a preliminary study, by G. S. Rice, 1912. 51 pp., 1 fig. 5 cents.

Technical Paper 47. Portable electric mine lamps, by H. H. Clark. 1913. 8 pp. 5 cents.

Technical Paper 101. Permissible explosion-proof electric motors for mines; conditions and requirements for test and approval, by H. H. Clark. 1915. 14 pp., 2 pls., 1 fig. 5 cents.

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